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HYBRID POPLAR PLANTATIONS FOR FARM DIVERSIFICATION IN SASKATCHEWAN

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Hybrid Poplar Plantations for Farm Diversification in Saskatchewan

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Abstract/Summary

This report outlines knowledge gained from the project what is known about hybrid poplar and their current and potential use in Saskatchewan. This report is intended to serve as a summary of developed knowledge and as a basis for expanded discussions about potential development of hybrid poplar in Saskatchewan in the future.

Much is known about hybrid poplar as it relates to use in shelterbelts and its use as a plantation species in other areas of North America where it has been managed for over half a century. Much less is known about its use Saskatchewan as a crop. In the absence of specific local knowledge, the project has through experimentation developed knowledge and provided recommendations for poplar farming in Saskatchewan. Specific information is provided on most appropriate poplar stock types, weed management strategies, clone performance and description, and the response of poplar clones to application of hog manure liquids.

1.0 Executive Summary and Recommendations

There is a growing "Saskatchewan" interest in the culture and use of hybrid poplar in the province particularly under short rotation intensive culture. Early hybrid poplar plantation results are encouraging, however, there are many unanswered questions regarding the development and performance of hybrid poplar planting stock and the farm practices required to ensure growth and performance. It is important that biotic and abiotic factors impacting the success or failure poplar farms are considered. This project has studied, in detail, early growth of poplar clones, weed management practices, stock types and factors influencing establishment, vulnerability to low temperature injury and insect, disease and other pest problems. The major outcomes of the project were:

1. Four three research and demonstration poplar plantations were established in the northern agricultural zone of Saskatchewan.
2. Cultural practices for the establishment of hybrid poplar plantations were studied.
    a. The optimal stock types for establishing hybrid poplar plantations in Saskatchewan were determined.
    b. Optimal weed management intensities and techniques were developed.
    c. Data was collected to support minor use registration of herbicides for use in hybrid poplar farms.
    d. Field rooting of hybrid poplar cuttings was studied
3. Elite trees developed by PFRA were evaluated under various site conditions in Saskatchewan and preliminary recommendations on poplar clones made.
4. Theresponse of poplar clones to application of hog manure liquids was studied.

This project is primarily concerned with the development of poplars and management practices for poplar farms or environmental roles. While a solid stand of poplars may not be ideal for all situations, establishing poplars on Saskatchewan farms certainly have benefits. Poplars have the potential to provide additional income to the farm in a variety of scenarios including a source of wood chips, fibre, sawlogs, veneer and other wood products. The attraction of poplar is mainly due to its rapid growth and short time period from planting to harvest. Opportunities for poplars, besides using the species as a wood source include environmental benefits, such as greenhouse gases mitigation (carbon storage), field, farmstead and roadside shelterbelts, riparian zone protection and wastewater management and interception of airborne particulates and odours. The environmental importance of poplar can not be understated. Because of the unique characteristics of poplar particularly their rapid growth and incessant capacity to take up water and nutrients makes this genus especially suited to bio-filtering roles and phyto-remediation.

Based on experiences from the project, the following are some suggested ways poplars can be used in the Saskatchewan agroecosystems.

- *Poplar Farms* - Poplar farms are an excellent source of wood material that help divert harvests from state, federal, and other recreational forest land. Planting marginal agricultural lands to poplars can create a woodlot with harvestable fiber (for pulp) in as little as 20 years under ideal conditions. After harvest, the stumps can resprout (called coppice) and grow for another rotation. If more valuable hardwoods are desired, such as black walnut or oak, they can be interplanted with poplars. Poplars can be thinned from the plantation, thereby providing a return before other tree species are ready for harvest. Spacing is very important in these situations and will be determined by your intended market at maturity. For example, a solid stand of poplars can be planted as close as 3 x 3 meters for pulp, but a wider spacing would be recommended if lumber or veneer is desired.

- *Shelterbelts* - Sheltgerbelts serve many purposes including crop/field protection, building shelter, erosion control, snow management, natural screening, wildlife corridors, and livestock protection. Although a shelterbelt of solid poplars is not recommended in most situations, poplar is an ideal component. Because of their extremely fast growth rates, poplar trees are a great way to quickly establish a shelterbelt structure. Planting other hardwoods, conifers, and shrubs alongside poplars will ensure a long-lived shelterbelt system. Poplars can be harvested from shelterbelts periodically for timber, firewood, etc. and may be allowed to coppice and re-grow.

- *Silvopasture* - Combining trees, forage crops, and livestock is not a new idea; although, it is rather uncommon in Saskatchewan. But silvopastoral systems involving poplar trees certainly are feasible here. Studies and observations indicate that poplars planted on a wider spacing, such as 10 x 10 meters, can be grown in conjunction with various forages. The animals benefit from cooling shade in the summer. Care must be taken with spacing, and grazing animals must be prevented from damaging the trees (by browsing, rubbing, etc.) until the trees are large enough to withstand minor disturbances.

- *Riparian Buffers* - Buffers along waterways, such as rivers and streams, serve to stabilize streams and slopes and help provide ideal aquatic habitat. When buffers are placed down-slope from fields, feed lots, manure and pesticide storage facilities, they act to trap sediments, nutrients, and/or pesticides. Though not the only option, poplars are well suited to quickly colonize and revegetate riparian borders that have been cultivated for annual crops. Many studies have examined poplar in buffer systems and have found them to be excellent candidates as the tree species. Poplars are effective at nitrate uptake, and the roots aid in soil stabilization which in turn slows soil erosion, phosphorous leaching, and pesticide movement.

- *Phytoremediation* - Phytoremediation strategies employ trees, shrubs and/or grasses for treating contaminated air, soil or water. These strategies include buffers, vegetation filters and *in situ* phytoremediation plantings. The key to phytoremediation success is predictable plant water uptake. Plants take up essentially all nutrients as water-soluble compounds through the roots or foliage. Poplars are one of the most common tree species used for phytoremediation because they grow rapidly, have many deep roots and take up large wuantities of water. Possible phytoremediation opportujities for poplar inlcude vegetation filters for wastewater treatment, vegetation caps over landfill waste and ins situ phytoremediation for subsurface treatment of inorganic or organic chemical spills.

- *Bioenergy* - Poplars are environmental sources of biomass for bioenergy. Poplar woodchips and/or pellets can be mixed (co-fires) with coal to produce electricity. Another bioenergy heating application may be small-scale close-couples gasifiers for farm and home use. These systems convert biomass to energy with good fuel efficiency, minimal maintenance and low cost while minimizing environmental problems.

Risks Associated with Poplar Farming

In any crop production system there are risks involved that can reduce productivity and prevent the land-owner from achieving the returns on investment needed to justify growing the crop. With hybrid poplars the greatest risk is a potential crop failure due to poorly selected or poorly managed stock. We can expect that climatic events will cause significant losses in hybrid plantations. Additional losses will likely result from growth-limiting diseases or insect infestations.

Large plantations of a single or of very few clones are at elevated risk of catastrophic loss because the degree of genetic diversity needed to resist attacks from biotic or abiotic agents is lacking: i.e. if one tree succumbs, all trees in the same clone are likely to succumb. The risk of loss in hybrid poplar can be reduced by using careful clonal deployment. This would include putting a limit on the extent of a single clone in any one year or in any region and using a wide array of clones instead of only one or two. The use of a comprehensive clonal selection system in co-operation with other growers, nurseries, breeders, and extension specialists is recommended. Diverse parentage of clonal material also allows the grower to match the characteristics of specific clones with the conditions occurring on different sites.

There is also a potential risk of loss associated with the poplar farm management regime because the timing of maintenance operations is critical and if an operational window for a cultural treatment is missed (for example, a rainy spring and a wet summer prevents mechanical weed control or site preparation), then the growth rate of crop trees could be compromised and it may take an additional year or two for the crop to get to marketable size.

Over the past half of a century, growers of hybrid poplar in other regions of North America have been blind-sided by unanticipated climatic events (e.g. floods or ice storms) or by new pests (e.g. insects, *Melampsora* leaf rusts, meadow voles, moose, beavers, etc.) While some of these losses can be predicted and anticipated, most are unprecedented and episodic in nature. Especially in Saskatchewan, where we are introducing new species and new management systems to the area, we can expect to encounter unanticipated losses over the first few years of operations. The key is to be aware of potential risks and prepare for them through breeding programs and other applied research associated with poplar growth and culture in the prairie environment.

Main Project Findings

The project has provided valuable information on hybrid poplar farming in Saskatchewan. As a result of the project we are more aware of the risks associated with poplar farming. Climate, wildlife damage and weed management have been the main risk factors in the first three years of the project. The following are main findings:

1. Poplar trees are extremely sensitive to climate induced risks such as drought and variable temperature during fall and spring. Drought combined with poor weed management practices can result in significant growth reduction. During the project period, one (2002) of the four years were extremely dry, these drought conditions significantly reduced early growth of poplars at the test sites.

2. Clone selection for poplar farms in relation to cold hardiness is very important. We were able to categorize the vulnerability of hybrid poplar clones to low temperature damage. It was somewhat alarming that Walker poplar, a clone widely planted in poplar farms, is vulnerable to low temperature injury. During the project this vulnerability was evident in that significant low temperature dieback of the Walker clone occurred in two out of four years. However, some of the new clones being developed by AAFC-PFRA were very hardy and unaffected by low temperatures.

3. The project has shown that weed management is key element of a poplar farming operation. Poplars do not compete with weeds until a canopy or crown closure develops. Weed management is not an easy task, as there are few registered herbicides and cultivated land hosts huge weed seed banks that

quickly come to life once the site has been disturbed. We examined different intensities of weed management as well as different weed control methods. Project results showed that effective weed management program will more than double the growth of poplar crops and without weed control no poplar crop will be produced. Simply stated poplar farming is not possible without weed a weed control program. The project results indicate that a minimum of two years of weed control is required and that growth are further enhanced if weed control is extended to four years. Our preliminary results suggest that between row tillage is as important as in row weed control. More research focusing on weed control method is required before specific recommendations can be made.

4. The stock type study has shown us that planting hardwood cuttings is extremely risky and therefore, not a recommended practice for Saskatchewan. This is contrary to results found in other regions of North America where poplars are grown. Bare root and rooted plugs stock types have performed well with similar results.

5. Strong clonal differences were observed in root initiation and growth in response to soil temperature. In all cases 14°C was the minimum threshold for root initiation and 18° to 22° was optimum for root growth. The lack of relationship between bud burst and root growth initiation resulted in big differences in the lag time between bud burst and root growth initiation among clones. This imbalance between root initiation and bud burst was bigger at lower than higher soil temperatures. Thus, care should be taken when planting clones with big lag phases, such as Walker, when soil temperatures are still low particularly under conditions of limited soil moisture.

6. Clone tests have identified several cones that have above average performance and growth. Results from project tests have consistently shown the top performing clones to be *P.* xWP-69, *P.* xKatepwa, P. xWalker and *P. tristis* 'SBC'. These tests have shown that these clones are well adapted to the unique growing conditions found in Saskatchewan. Most clones used in other regions of North America and tested at the project sites proved unsuitable because they lack hardiness for the extreme climate and short growing season of the prairies. Performance of clones varied according to site however these clones were among the top ten at all project sites. Meadow Lake site A was consistently the best site for poplar growth. The project has shown that the genetic base of poplar needs to be expanded to provide suitable clones capable of growing on a wide range of sites.

7. Insect and disease surveys have shown that to date insects pose a limited threat, however, disease problems related to leaf rusts and septoria canker are becoming a serious concern. There appears to be limited resistance in poplar clones commonly planted in Saskatchewan. It is highly possible that clones that are showing good performance now could potentially fail midway in the rotation because of their susceptibility to disease.

8. Liquid hog manure was applied in the hog effluent study at Arborfield. Addition of manure had little impact on poplar growth except for the clone *P.* xWP-69 which showed a positive response to manure application. It appeared that the amount of manure applied was no where near the tolerable limit that could have been applied. More research on the quantities of hog manure that can be applied to poplar clones is required.

Recommendations

1. Overall the results of the project have shown that there are a number of significant risks that need to be addressed if poplar farms are to be successful or can be considered an opportunity for Saskatchewan farmers. The project has shown that, while poplars have potential, considerable work remains before poplars can be thought of as a reliable crop for Saskatchewan. The greatest threats include abiotic and biotic stresses specifically drought, low temperature injury, wildlife damage and

disease. Until these threats are addressed and solutions found large scale deployment of poplars on the agricultural landscape is a major risk.

2. Reliance on a limited number of poplar clones poses a significant risk. Embarking on a large scale planting program with the current poplar clones available would entail considerable risk as most of the clones available were bred and developed for shelterbelt and other environmental planting with little or no consideration given to plantation requirements or the growing conditions associated with this use. Recently the AAFC-PFRA has initiated a poplar breeding program designed to increase the genetic base of poplars for use in the prairie region, this project has progressed but is still in early stages of development. To assist with this breeding program development of molecular genetic techniques that will allow for identification of candidate genes for key adaptive traits is highly recommended. This would significantly shorten the time required for testing and subsequent deployment of new adapted poplar clones. Recently the poplar genome was mapped, this breakthrough could lead the way for accelerating the breeding process. What is required is a genomic project aimed at identifying genes responsible for a wide variety of traits, including *Septoria* and *Melampsora* resistance, pest resistance, water use efficiency, cold and drought resistance, and nutrient use efficiency. To accomplish this funding is required to bring genetic resources together under a common umbrella, and provide a pipeline to analytical resources and 'recipes' for analysis of individual traits by poplar breeders.

3. Weed management is the most critical cultural practice in poplar farming. **Without weed control poplar farming is not possible.** The absence of registered herbicides for poplar farms is a significant impediment to farming poplars as a crop. Without reliable herbicides weed control is labour intensive and costly directly impacting the cost of establishing poplar farms. Obtaining herbicide registration for poplar farming must be given high priority.

4. Disease, particularly septoria canker (*Septoria musiva*), will be a serious problem that potentially could wipe out entire poplar farms in mid rotation. It is apparent that Walker poplar as well as other predominate clones used in the prairies ie. Northwest and, Brooks #6 are highly susceptible to septoria. Other potentially damaging diseases include melamspora rust (*Melamspora medusae*) and septoria leaf spot (*Septoria musiva*) Breeding programs must address this problem by introducing screening tools to identify resistant genetic lines.

2.0 Technical Report

2.1 Project Site/Climate Description and Plantation Weed Control

Site Characteristics

Test sites were established at Meadow Lake (MLA & MLB), Star City and Arborfield. Sites MLA and MLB were located about 25 kilometers southwest of the town of Meadow Lake (MLA: NW 22 58 19 W3; MLB: SW 31 57 19 W3). The other sites are located near the towns of Star City (NW 36 45 17 W2) and Arborfield (NE 4 46 12 W2).

Although the topography of all sites is very gently undulating (slopes less than 2 percent), the soil and site characteristics are diverse (Table 1). According to Poplar Site Suitability classification the MLA was classified as highly suitable and MLB, Star City, Arborfield site were classified as suitable (See attached suitability maps in Appendix).

Meadow Lake A (MLA)

This site is located on private land owned by D. Cubbon. Previous land use was agriculture with alfalfa seed production the main crop for the five years prior to planting poplars. The site is protected on the south side by a native aspen woodlot. This site includes the stock type study, weed control intensity, large and small plot clone tests and a block of four poplar clones for future research.

Meadow Lake B (MLB)

This site is located on private land owned by W. Culbert. Previous land use was agriculture was tame grass pasture. This site includes the stock type study, weed control method and large and small plot clone tests.

Star City

This site is located on land owned by Kelsey Pork Farms. Previous land use was cereal/oilseed production. The poplar tests are planted as block shelterbelts around a commercial hog barn. This site includes large and small plot clone tests.

Arborfield

This site is owned by Pasquia Pork Products. Previous land use was cereal/oilseed production. The poplar tests are planted as a block shelterbelt on the north side of a commercial hog barn. This site includes the small plot clone test and the liquid swine manure test.

Table 1: Project site characteristics

Site	Area (ha)	Previous Crop	Poplar Suitability Classification	Soil Characteristics				
				Association	Soil Type	Texture	pH	EC (mS/cm)
MLA	16.2	Alfalfa	Highly Suitable	Loon River	Orthic Gray Luvisol	Sandy-loam to loam	6.5	0.8
MLB	14.3	Pasture	Suitable	Bittern Lake	Bruvisolic Gray Luvisol	Sandy-loam to loam	5.4	0.7
Star City	4.5	Canola	Suitable	Melfort Hoey	Orthic Black Chernozem	Clay-loam to Loam	5.1	0.8
Arborfield	4.3	Wheat	Suitable	Eldersley	Orthic Gray Luvisol	Clay-loam to Loam	6.3	0.6

2002 - 2005 Weather Conditions

Weather data was collected with on-site weather stations at the two Meadow Lake sites whereas fro Star City and Arborfield sites similar data was obtained from the closest Environment Canada weather stations .Weather condition varied considerably over the project period. Rainfall was the most variable climatic factor ranging from drought conditions to excessive rainfall. Generally, 2002 – 2004 were considerably drier than normal whereas 2005 was received above average rainfall (Figure 1). The variable rainfall had a significant impact on early poplar growth at all sites.

Temperature conditions were within normal ranges for all test sites. In 2002 and 2003 a cold period at the Meadow lake sites in late September early October where temperatures dropped below -8°C resulted in significant low temperature injury in a number of clones including P. xWalker.

Figure 1: Four year growing season precipitation at project sites

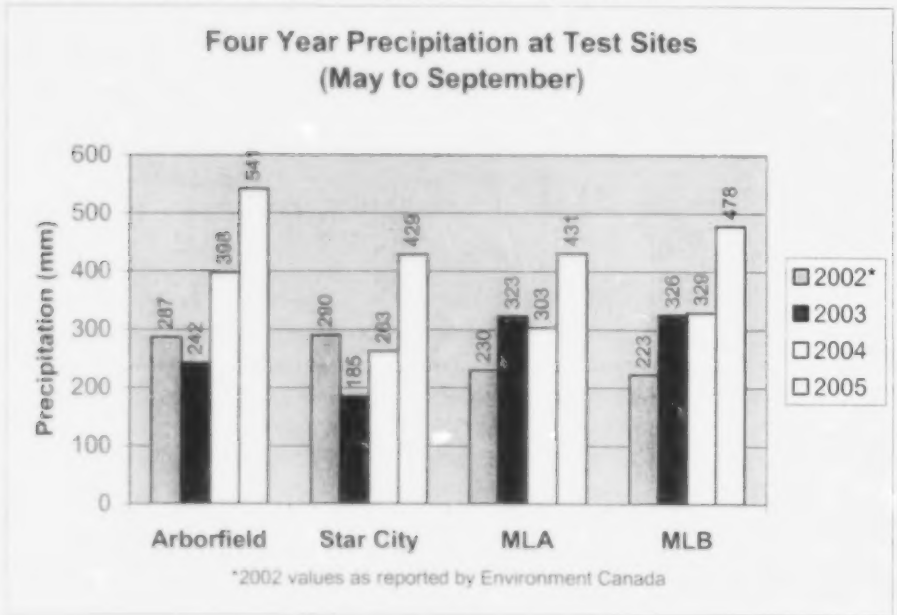


Figure 2a: Maximum and minimum temperatures recorded at Meadow Lake project sites in 2002.

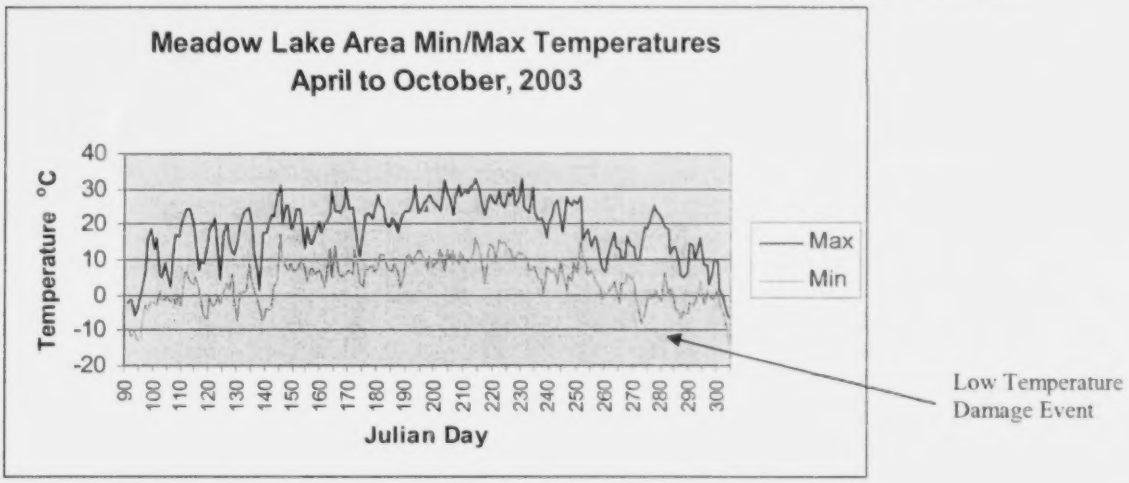
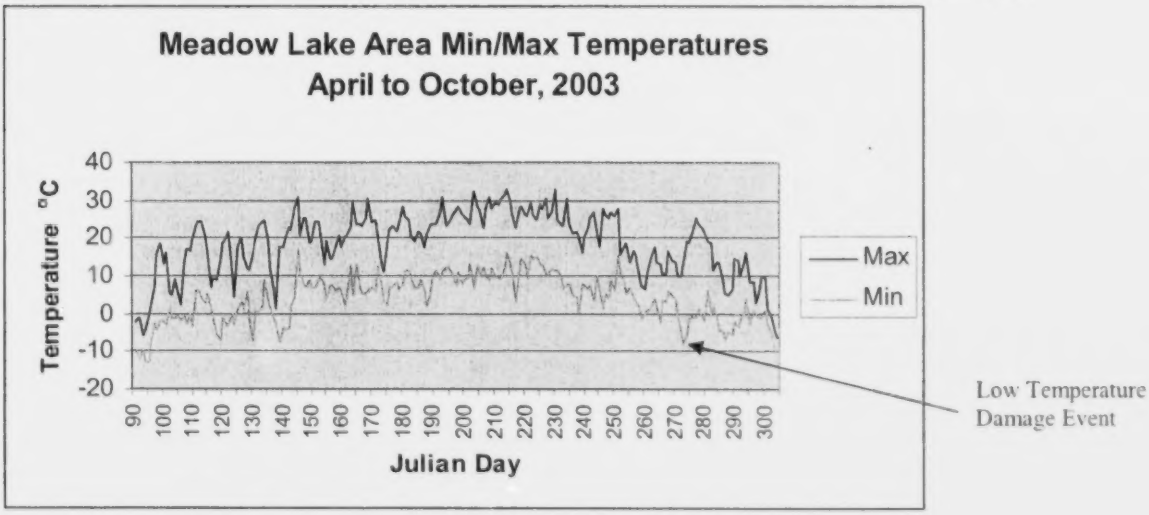


Figure 2b: Maximum and minimum temperatures recorded at Meadow Lake project sites in 2003.



Summary of Project Weed Control Program

Weed control is necessary for growth and survival of poplar trees. Controlling weeds reduces competition for water, nutrients and light as well as eliminates cover for rodents. Our goal was to achieve a minimum 80 percent weed free plantation during the project resulting in a survival rate of 90 percent. During the project we recorded the dominant weed species present at the project site. Annual weeds dominated in the first two years, but were gradually replaced by perennial weeds. Weed control strategies used were dictated by the predominate weed species present. In years one and two, with annual weeds predominating, we focused on cultivation; whereas in years three and four perennial weeds dominated and our strategy shifted to post emergent control using glysphosate and mowing.

Year One Weed Control (2002) - In year one, weed management involved the use of a three-point-hitch mounted tandem disc to level the field and remove trenches and mounds left by the planter and to mechanically control weeds. Table 1 lists the main weed species present at each project site. In year one, the

plots were disced four times, this provided a degree of weed control between rows however the in-row weeds were not controlled. Linuron herbicide was applied to the rows in October.

Table 1: 2002 Site Preparation and Weed Control Program

Site	Site Preparation	Weed Control
Meadow Lake A	Glyphosate applied in fall 2001 Site deep tilled once followed by light cultivation	Glyphosate applied with directed spray in mid July Culivate two times (mid-August, mid-Sept) Linuron applied Oct 22
Meadow Lake B	Glyphosate applied spring 2002 Site deep tilled twice and rocks removed	Glyphosate applied with directed spray in mid July Tandem disc once (late Aug), cultivate once (mid-Sept) Linuron applied Oct 23
Star City	Tandem disc two times - spring 2002	Trifluralin-Metribuzin applied pre-planting Tandem disc once Linuron applied Oct 15
Arborfield	Tandem disc two times - spring 2002	Trifluralin-Metribuzin applied pre-planting Tandem disc once Linuron applied Oct 15

Year Two Weed Control (2003)- In year two we focused on mechanical weed control using a disc (Table 2). The plots were disced three times during the growing season. The disc was too large to fit between the trees in-row for weed control, and constant between row discing had left large trenches on either side of the young poplar rows. The presence of in-rows weeds and between-row weed regrowth in spite of intense mechanical cultivation necessitated a change in weed control strategy. In the fall we began using a small rotary field mower to control the in-row weeds. As in year one, linuron herbicide was applied to the tree rows in October.

Table 2: 2003 Weed Control Program

Site	Weed Control Method
Meadow Lake A	**Glyphosate** - Enviromist sprayer at a rate of 2.5 litres/ha - Two times: June, July **Linuron** -'U' boom sprayer at a rate of 4kg/ha - October 15 **Tandem disc** - Two times: June, July **Mowing** - Two passes: July, August
Meadow Lake B	**Glyphosate** - Enviromist sprayer at a rate of 2.5 litres/ha - One time: July **Linuron** -'U' boom sprayer at a rate of 4kg/ha - October 16 **Tandem disc** - Three times: June, July, August **Mowing** - Two passes: July, August
Star City	**Glyphosate** - Enviromist sprayer at a rate of 2.5 litres/ha - One time: July **Linuron** -'U' boom sprayer at a rate of 4kg/ha - October 21 **Tandem disc** - Two times: July, August **Mowing** - One pass: October
Arborfield	**Glyphosate** - Enviromist sprayer at a rate of 2.5 litres/ha - One time: July **Linuron** -'U' boom sprayer at a rate of 4kg/ha - October 22 **Tandem disc** - Two times: July, August **Mowing** - One pass: October

Year Three Weed Control (2004) - In year three the in-row weeds were removed by mowing in May prior to active weed growth. This removed dried weeds and exposed the soil stimulating a flush of new weeds within one week of mowing. This allowed for control of in-row weeds by cross spraying the plots with glyphosate. The new weed management strategy was to 'chemical fallow' the planting using a shielded sprayer (Enviromist) to apply glyphosate. The key to this practice was the availability of the shielded sprayer which allowed precision application of glyphosate with minimal drift. A total of three glyphosate spraying operations were required at the two Meadow Lake sites, whereas two operations were required at Star City and Arborfiled. Each operation included spraying the plots in both directions and required three hours/hectare to complete. At Meadow Lake a single application of Quizalofop-p-ethyl was required for Canada thistle control.

Table 3: 2004 Weed Control Program

Site	Weed Control Method
Meadow Lake A	Glyphosate applied with directed spray - three times (June, July, August) - Enviromist sprayer at a rate of 2.5 litres/ha Quizalofop-p-ethyl applied with directed spray - one time (July) - Nifty 50 sprayer/wand at a rate of .37 l/ha
Meadow Lake B	Glyphosate applied with directed spray - three times (June, July, August) - Enviromist sprayer at a rate of 2.5 litres/ha Quizalofop-p-ethyl applied with directed spray - one time (July) - Nifty 50 sprayer/wand at a rate of .37 l/ha Mowing – One pass: May
Star City	Glyphosate applied with directed spray - two times (June, July) - Enviromist sprayer at a rate of 2.5 litres/ha Mowing –One pass: November
Arborfield	Glyphosate applied with directed spray - two times (June, July) - Enviromist sprayer at a rate of 2.5 litres/ha Mowing – One pass: November

Year Four Weed Control (2005) - In year four, due to the success attained in year three, the 'chemical fallow' strategy using the shielded Enviromist sprayers was used again (Table 4). At the Meadow Lake sites mowing took place early in the season and cross spraying glyphosate was key to good weed control. Only two applications were required as weed control in the previous season was excellent. At the Star City/Arborfield sites heavy rainfall kept the plots too wet to gain entry for a portion of the season. This meant two passes with the mowers was needed and weather only allowed for one application of glyphosate. By the end of the season weed control was good.

Table 4: 2005 Weed Control Program

Site	Treatment
Meadow Lake A	Glyphosate - Enviromist sprayer at a rate of 2.5 litres/ha - Two applications: June, August Mowing - One pass: June
Meadow Lake B	Glyphosate - Enviromist sprayer at a rate of 2.5 litres/ha - Two applications: June, August Mowing - One pass: June
Star City	Glyphosate - Enviromist sprayer at a rate of 2.5 litres/ha - One application: August Mowing - Two passes: July, August
Arborfield	Glyphosate - Enviromist sprayer at a rate of 2.5 litres/ha - One application: August Mowing - Two passes: July, August

2.2 Wildlife Damage

Wildlife damage can pose a serious threat to economic production of hybrid poplar. There are many species of wildlife that can cause damage by browsing or physical contact, this includes rodents, rabbits and ungulates. It is important that an effective management strategy be in place to address wildlife damage issues. Integrated pest management (IPM) can be used to effectively manage wildlife damage in poplar farms. Critical to successful IPM are pest population and damage monitoring, determination of economic thresholds for control and the integration of various control measures. Monitoring pest populations and damage on a regular basis is essential in order to minimize damage. At the same time data on tree damage needs to be collected. This allows for determination of economic thresholds when wildlife control outweighs the costs of implementing control methods.

During the winter of 2003-04 and to a lesser extent in 2004-05, wildlife damage, especially ungulate (deer and moose) browsing, was significant at the two Meadow Lake project sites, . The damage has adversely impacted tree growth and form. Affected trees were browsed to the snow line negating growth in 2003 and resulting in multiple stems. There did not appear to be browsing preference between clones. So far there has been no evidence of widespread rodent or rabbit damage. Management options being considered include use of lure crops, physical protection and repellents.

2.3 Pest Survey of Poplar Plantations in Saskatchewan

Introduction

Pest surveys of hybrid poplar plantations are required to gain an understanding of potential pest problems that may affect the productivity and health of hybrid poplar plantations in Saskatchewan. The objective of this study was to survey hybrid poplar farm test sites to identify and gain knowledge of insects and diseases that may affect the productivity and health of these test plantations in Saskatchewan. From 2002 to 2005, annual pest surveys were conducted at each of the project sites. The survey involved a detailed examination of the leaves, branches and trunk for the presence of insects and disease on approximately six percent of the plants at each site. Surveys were conducted on plants selected prior to the survey and were selected based on an even distribution throughout each plot.

Insect Survey

During the four year survey the insect that caused the most damage in hybrid poplar plantations was the gray willow leaf beetle (*Tricholochmaia decora*) but overall they caused only minimal defoliation. Numerous leafrollers and leaftiers were recorded during the surveys with four identified; green aspen leafroller (*Apotomis removana*), lined black aspen caterpillar (*Xylomyges dolosa*), obliquebanded leafroller (*Choristoneura rosaceana*) and rustylined leaftier (*Clostera albosigma*). There were other species of leafrollers and leaftiers present but they were found in such low numbers they could not be identified. Four species of leafminers were commonly found during the surveys; aspen serpentine leafminer (*Phyllocnistis populiella*), cottonwood leafmining beetle (*Zeugophora scutellaris*) and two unnamed species (*Messa leucostoma* and *Phyllonorycter salicifoliella*). A list of insects found at the test sites are listed in Table 1.

Disease Survey

The most common diseases recorded during the four year survey was septoria leaf spot and septoria canker (*Septoria musiva*), cytospora canker (*Cytospora chrysosperma*) and melampsora leaf rust (*Melampsora medusae*). In 2005, for the first time, *Venturia populina* was identified at the Meadow Lake plantation. The major diseases found in survey are described below:

Septoria leaf spot: Septoria leaf spot is widely distributed in Canada. The disease is common on native and hybrid poplars commonly grown in windbreaks. Symptoms of leaf spot may vary: brown, mostly circular spots; small flecks with angular margins; white or silvery spots 1 to 3 mm in diameter; irregularly shaped large spots that are light tan in the center, with a dark brown margin. The fungi overwinters in dead leaves and twigs infected the previous growing season. Initial infection in spring are release from fungal fruiting structures on fallen infected leaves. Numerous infections can result in premature defoliation of susceptible trees.

Septoria canker: Septoria canker (*Septoria musiva*) is widely distributed in Canada. The disease is common on native and hybrid poplars commonly grown in windbreaks. Cankers are formed on the main stem and branches of the current season's growth, usually within 5 feet of the ground. Marginal swelling of most cankers occur in the following summer when new sapwood is formed. Cankers are often flat-faced, or have swollen marginal callus. The bark of young cankers is dark brown or black and depressed. Continued development of cankers may result in girdling and death of affected stems during late summer.

Venturia populina: This disease is widely distributed throughout the prairie provinces. The main host is balsam poplar, but aspen and Katepwa poplar are also known to be a host. Typical symptoms are a blackening and wilting of young shoots and leaves. Often the blackened shoots will bend downward, producing a shepherd's crook. Infection on young trees may cause the trees to be disfigured and growth severely affected. Infection on larger trees is rare and does not significantly affect their growth.

Cytospora sp.: Cytospora canker is widespread in North America, occurring on most species of *Populus* throughout their range. Cytospora canker infects only through wounds or other openings in the bark. It is considered a weak parasite, and most often attacks stressed tress, such as those growing on poor sites or injured by drought, frost, sunscald, hail, severe pruning, fire, insect or mechanical damage. Cytospora canker causes branch dieback and cankers on trees of any age. Cankers on trunks and limbs are often elongate, slightly sunken, discolored areas in the bark. Infected bark may be yellow, brown, reddish-brown, gray, or black. Bark often splits along to canker margin because of callus formation by the host.

Summary

At the present time insects do not appear to be a serious threat to poplar farms. The exception may be forest tent caterpillar infestations that can occur on a cyclical basis. During a high infestation of forest tent caterpillars significant defoliation and associated growth reductions can be expected, however the impacts are not expected to result in mortality or long term damage. Other defoliators that may cause periodic problems are cottonwood leaf beetle and the gray willow leaf beetle, however as for the forest tent caterpillar the damage is not expected to have long term impact. Boring insects were not observed and not considered to be a serious threat tat this time.

Stem and foliar diseases present a major threat to poplar farms in Saskatchewan. The most limiting disease of hybrid poplar in eastern Canada is stem canker caused by *Septoria musiva*. This fungus also causes leaf spots and branch cankers, but the stem cankers are the primary concern. In these regions stem canker has resulted in plantation failure. Previously this disease was not considered a serious threat in the prairies, and as a result genetically susceptible clones have been successfully grown in prairie shelterbelts. Recent experiences in this project as well as in other plantations have shown that Septoria stem canker is present and causing significant damage to some commonly used clones. The other diseas commonly found is the leaf rust *Melampsora medusae*. Damage from this disease occurs late in the growing season and seldom results in growth reduction or mortality.

Table 1: Insects identified feeding on hybrid poplar at project sites 2002 to 2005

Common name	Scientific name
American hornet moth	*Sesia tibialis*
Aspen serpentine leafminer	*Phyllocnistis populiella*
Black-cheeked aspen caterpillar	*Ipimorpha pleonectusa*
Black willow aphid	*Pterocomma smithiae*
Canadian tiger swallowtail	*Pterourus glaucus canadensis*
Chafer beetle	*Dichelonyx* sp
Cottonwood leaf beetle	*Chrysomela scripta*
Cottonwood leafmining beetle	*Zeugophora scutellaris*
Flea beetles	*Phyllotreta* and *Crepidodera* sp
Forest tent caterpillar	*Malacosoma disstria*
Goat sallow	*Homoglaea hircina*
Grasshoppers	Various species
Gray willow leaf beetle	*Tricholochmaia decora*
Green aspen leafroller	*Apotomis removana*
Green aspen leaftier	*Pandemis canadana*
Grieving woodling	*Egira dolosa*
Leaf folding sawfly	*Phyllocolpa agama*
Leafminer	*Messa leucostoma*
Leafminer	*Phyllonorycter salicifoliella*
Lined black aspen caterpillar	*Xylomyges dolosa*
Obliquebanded leafroller	*Choristoneura rosaceana*
Poplar and willow leaf weevil	*Lepyrus canadensis*
Poplar petiole-gall aphid	*Pemphius populitransversus*
Rustylined leaftier	*Clostera alboxigma*
Rusty tussock moth	*Orgyia antiqua*
Spotted poplar aphid	*Aphis maculatae*
Spotted tussock moth	*Lophocampa maculata*
Tarnish plant bug	*Lygus lineolaris*
Variable tussock moth	*Dasychira vagans*
Willow sawfly	*Nematus ventralis*
White admiral	*Basilarchia arthemis*

2.4 Poplar Farming Cultural Practices

2.4.1 Stock Types for Hybrid Poplar Farms in Saskatchewan

Introduction

This project is being conducted by AAFC-PFRA and the University of Saskatchewan with collaboration by Mistik Management and PRT (Pacific Regeneration Technologies). The study is replicated at the two Meadow Lake sites in Northwest Saskatchewan. The objective of the study is to investigate the effectiveness of different stock types for establishing hybrid poplar plantations in Saskatchewan.

Each of the stock type studies includes the following treatments: hardwood cutting, rooted plug and bare-root rooted cutting in a randomized complete block design. Each treatment is replicated three times. Thirty-six 40 x 50 m plots were established with Walker poplar planted at 3 x 3 metre spacing in each plot. Stock types were machine planted in the spring of 2002.

Results

The severe drought of 2002 had significant impact on tree survival especially the hard wood cutting stock type. Cuttings were replanted in 2003, but once again survival was low and as a result this treatment was discontinued in 2004 and removed from the study.

Table 1: Survival of Walker poplar in stock type study

Stock Type	Survival (%)	
	Meadow Lake A	Meadow Lake B
Hardwood Cutting	38	27
Rooted Plug	94	79
Bare root	93	85
Study Mean	75	64

Overall growth of the stock types was considerably lower than expected in year one and two. In 2004, total height increased two-fold for both treatments compared to year two. Growth rate increased further in 2005 (Figures 1 and 2). This can be attributed to higher precipitation and subsequent improved soil moisture conditions in 2005 as compared to other years. In addition, winterkill and wildlife damage prior to year two significantly impacted tree height in 2003 and 2004. Tree height after three growing seasons was significantly less than what was expected based on other test programs. However in 2005 trees had growth rates that approached 1.5 meters. The enhanced growth in 2005 has resulted in growth that is approaching what would be expected at these sites.

Growth of rooted plugs was greater than bare-root at the Meadow Lake A site, whereas the reverse trend was evident at Meadow Lake B, where the bare-root stock type had greater growth. Meadow Lake B was considered to be a lower quality site than Meadow Lake A.

Conclusion

The stock type study has shown us that planting hardwood cuttings is extremely risky and therefore, not a recommended practice for Saskatchewan. This is contrary to results found in other regions of North America where poplars are grown. The problem of poor rooting is related to poor rooting ability of clones such as Walker and that high soil temperatures (>15^{0}C) are required before cuttings will root. Bare root and rooted plugs stock types have performed well with similar results.

Figure 1: Growth of Poplar Stock Types (Height)

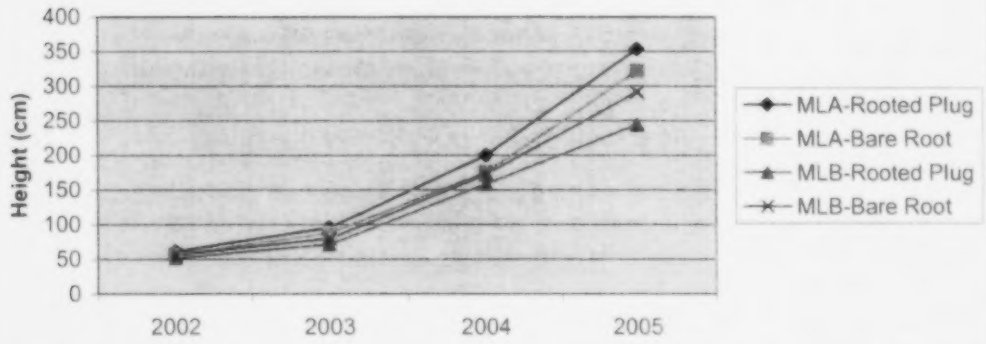
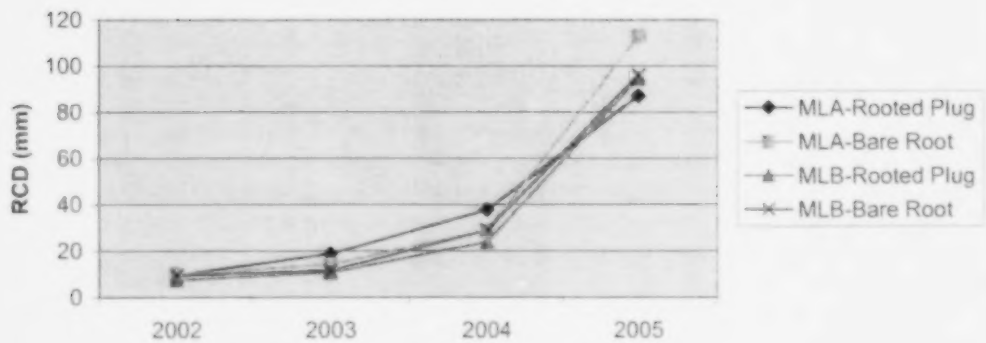


Figure 2: Growth of Poplar Stock Types (RCD)



2.4.2 Soil Temperature and Rooting of Hybrid Poplar Clones

Background:

The rooting ability of cuttings of woody species is under strong genetic control; species, genotypes and clones differ in their ability to root. It is recognized that this rooting ability can also be affected by the physiological condition of the cuttings (Heilman et al. 1994, Welander et al. 1994, Wilcox and Farmer 1968) and possibly other environmental factors such as soil temperature and moisture conditions. Thus, some of the differences in growth and drought tolerance among clones under a variety of soil conditions may be related to differences in root growth and formation. An early and effective root growth from cuttings, for example, would give the seedling a head start on capturing and exploiting soil moisture and nutrients ensuring survival and a good early growth. A late root growth preceded by an early shoot growth, on the other hand, would predispose the new seedling to water stress and possibly mortality, if soil moisture becomes limiting.

Although much effort has been devoted to examining physiological factors influencing and genetic differences in rooting of hybrid poplar cuttings, much less attention has been given to the effects of soil temperature. Soil temperature has a significant impact not only on the initiation of new roots but also on the development of root systems. Observations indicate that the number of roots developed on a cutting is under strong genetic control and is unaffected by the rooting temperature (Bloomberg 1963, Welander et al. 1994). Soil temperature, however, affects the rate of initiation and growth of roots on cuttings; at the lower temperature threshold, root initiation is delayed and root growth rate slowed. There also appears to be strong genetic differences in this temperatures threshold and optima for root growth on cuttings of various species (Bloomberg 1963, Welander et al. 1994). Soil temperature is, therefore, likely to play a major role in the differences in rooting of cuttings of different hybrid poplar clones. This may, in turn, affect the growth rate and survival of the planted seedlings. The objective of the study was, therefore, to examine the rooting responses of hardwood cuttings of hybrid poplar clones to different soil temperatures. Knowledge of the rooting characteristics of cuttings of different hybrid poplar clones should help in matching clones to specific site conditions and in developing appropriate cultural regimes for specific clones.

Materials and Methods:

In early February, whips of ten different clones of hybrid poplar were obtained from stooling beds here at Indian Head. The whips were then cut into 7.5 cm cuttings each with at least one bud and between 10 and 15 mm in diameter. The cuttings were kept in cold storage at –4°C until the initiation of the study, 2 ½ months later. The following poplar clones were used for the study: Assiniboine, Brooks #1, CanAm, Hawktree, Hill, Katepwa, OPW 210L-71, Walker, WP69 and WT 66V. Brooks1, CanAm and OPW 210L-71 were, however, not used for the detailed study.

The cuttings were soaked in water overnight at 10° C then grown in a peat moss:vermiculite media (pH ~ 6) at six different temperatures: 10°, 14°, 18°, 22°, 26° and 30° C. Twenty cuttings, five in each pot, were planted in 3 L pots (for a total of four pots per clone and temperature). Number of roots initiated and the total length of all the roots were assessed on these cuttings after 2 and 3 weeks under the different growth conditions. Days to bud burst and initiation of root growth were determined on another set of 10 cuttings from each clone, separately potted and grown at 14° and 22° C. Root initiation and bud burst was considered complete when 50% of the cuttings had initiated white tips (roots) or had one bud with green leaf tips visible.

Results and Discussion

Date of root initiation and bud break

There were big differences among clones in days to bud burst at the two soil temperatures (14° and 22° C) examined here (Table 4). The clone Assiniboine broke buds the earliest under both temperatures (10 and 8

days at 14° and 22° C, respectively), while Katepwa was the slowest (20 and 11 days, respectively). Days to root initiation also differed strongly among the clones under both temperature regimes although the differences were smaller at 22° C. The differences among clones was, however, bigger at 14° than at 22° C. There was no relationship between bud burst and root initiation; clones that broke their buds early did not necessarily initiate root growth early. For example, cuttings of Brooks#1, CanAm, OP180H and Walker clones initiated root growth after about 22 days at 14° C and yet their bud burst varied from 13 days (Walker) to 20 days (Katepwa) at the same temperature. This resulted in major differences among the clones in the lag period between bud burst and root initiation. These differences were particularly big at 14° C: in the hybrid Walker, for example, root initiation lagged behind bud burst by 10 days whereas in Hill and WP69 there was only a one-day lag. At a soil temperature of 22° C, however, the differences among the clones in the lag period were much smaller (ranging from 4 days to none) (Table 4). These results indicate that, at lower soil temperatures, there may be a higher risk of mortality in clones with bigger lag periods where or when soil moisture supply may be limiting. To minimize this risk, it is important that cuttings of the different clones should be planted when the soil temperature is 14° C or above, especially in years when soil moisture supply may be a problem.

Number of roots

The total number of roots produced on each 7.5 cm cutting was around 9 for all the clones except Hill and Hawktree which had about 12 roots each. This did not appear to be related to the diameter of the cuttings (data not shown), and therefore reflect clonal differences among the hybrids. There was no root initiation on cuttings of any of the clones at 10° C soil temperature even after three weeks of incubation (Fig. 4). Although it appears that 22° C was the optimum temperature for root initiation, with sufficient time (3 weeks for example), 18° C and 14° were equally good (Fig. 4). However, there were clonal differences in root initiation in response to soil temperature. For example, root initiation on cuttings of the clone Assiniboine, Hawktree and WP69 was quite good at soil temperatures between 14° to 26° C after three weeks, and between 18° and 26° C after two weeks. In Hill, Katepwa and Walker, however, the threshold for root initiation was a bit higher (18° and 22° C) regardless of the duration of incubation (Fig. 4).

Thus, although there was minimal root initiation on cuttings of all the clones after two weeks at 14° C, significant root initiation was observed in week three in all the clones except Walker and to a much less extent OP180H (Fig. 4). There, thus, appears to be a temperature threshold for root initiation at 14° C for most clones except Walker and Katepwa and to a much less extent Hill. The latter group has a higher temperature threshold of about 18° C (Fig.4). Soil temperatures of 26° C or over were not favourable for root initiation most likely as a result of competition for carbohydrate reserves by the higher rate of respiration and an early bud burst at the higher temperatures.

Total root length

The total root length produced on each cutting, at the optimum soil temperature, varied significantly (Fig. 5). Cuttings of the clones Hawktree, Hill, WP69 and WT66V produced the longest roots, while those of Assiniboine, Katepwa and Walker had the shortest roots. An early prolific root production combined with good length will permit the efficient exploitation of soil resources and likely put cuttings with abundant roots at an advantage. Whereas Assiniboine had a shorter total root length (about ½ of Hill), it initiated root growth much earlier than Hill, for example, at the lower soil temperatures (Table 4 and Fig. 4), thus displaying different strategies. The total root length on each cutting was not related to the date of initiation of root growth: Assiniboine and Walker, which had the shortest roots of all the clones, initiated root growth the earliest. These differences may therefore be genetically controlled although the physiological condition (such as carbohydrate levels) of the cutting may possibly have an impact.

Generally, 18° C soil temperature was found to be the optimum for root elongation in all the clones, although Walker appears to prefer a slightly higher soil temperature (22° C) than the other clones (Fig. 5). There was also significant root growth at 14° C in all the clones after three weeks of incubation. The temperature threshold for root growth is, thus, similar to that of root initiation (Figs. 4& 5). Higher soil

temperatures (above 22° C) was not favourable to root elongation. This is most likely the result of a combination of higher respiratory rates at higher temperatures and competition for reserves between root growth and shoot growth.

Conclusions:

Strong clonal differences were observed in root initiation and growth in response to soil temperature. In all cases 14°C was the minimum threshold for root initiation and 18° to 22° was optimum for root growth. The lack of relationship between bud burst and root growth initiation resulted in big differences in the lag time between bud burst and root growth initiation among clones. This imbalance between root initiation and bud burst was bigger at lower than higher soil temperatures. Thus, care should be taken when planting clones with big lag phases, such as Walker, when soil temperatures are still low particularly under conditions of limited soil moisture. It is possible that that some of the differences in root growth observed here, particularly at the higher soil temperatures, may be influenced by the physiological conditions of the cuttings, a factor we did not examine in this study.

Table 1:. Period to bud burst and root initiation on cuttings of various hybrid poplar clones at 14° and 22° C soil and air temperatures. Bud burst and root initiation were considered complete when 50% of the cuttings had white root tips or had one bud with green leaf tips visible.

Clone	Bud burst at 14°C, days	Bud burst at 22°C, days	Root initiation at 14°C, days	Root initiation at 22°C, days	Differences between root initiation and bud burst at 14° C, days	Differences between root initiation and bud burst at 22° C, days
Walker	13	8	23	11	10	3
Hill	15	9	16	11	1	2
Katepwa	20	11	22	12	2	1
WP-69	13	8	14	10	1	2
Hawktree	12	6	15	10	3	4
Assiniboine	10	8	15	9	5	1
WT-66V	13	11	16	11	3	0
Brooks#1	16	9	22	12	6	3
CanAm	15	8	21	9	6	1

References:

Bloomberg, W.J. 1963. The significance of initial adventitious roots in poplar cuttings and the effect of certain factors on their development. For. Chron. 39:279-289.

Heilman, P.E., G. Ekuan and D.B. Fogle. 1994. First-order root development from cuttings of *Populus trichocarpa* x *P.deltoids* hybrids. Tree Phys. 14:911-920.

Smith, N.G. and P.F. Wareing. 1974. The distribution of latent root primordial in stems of *Populusxrobusta*, and factors affecting the emergence of preformed roots from cuttings. Forestry. 45:197-209.

Welander, M. 1994. Influence of environment, fertilizer and genotype on shoot morphology and subsequent rooting of birch seedlings. Tree Phys. 15:11-18.

Wilcox, J.R. and R.E. Farmer. 1968. Heritability and C effects in early root growth of eastern cottonwood cuttings. Heredity. 23:239-345.

GROWTH TEMPERATURE (AIR AND SOIL) °C

Figure 1: Number of roots initiated on cuttings of various poplar clones after two and three weeks of growth at different temperatures (soil and air).

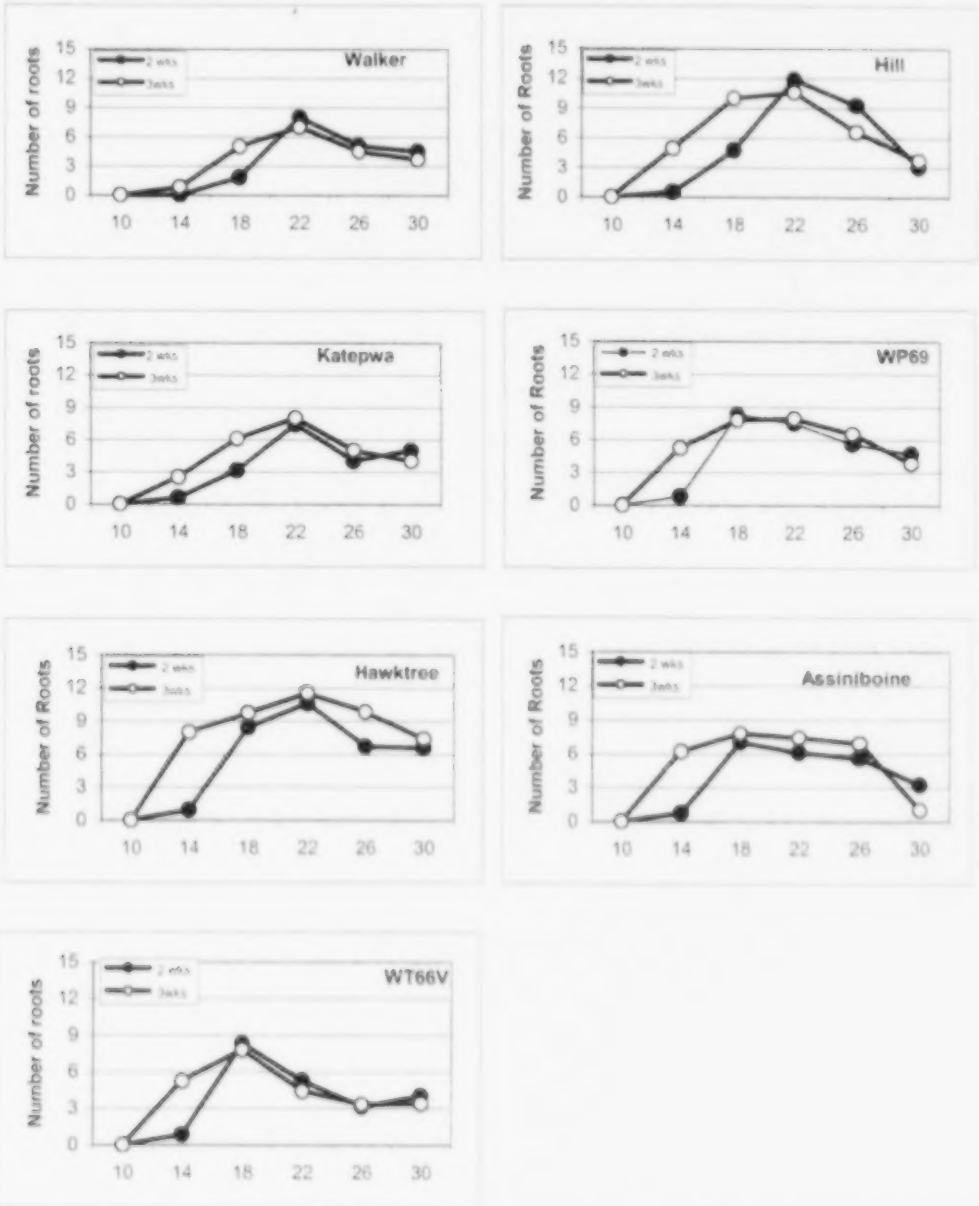
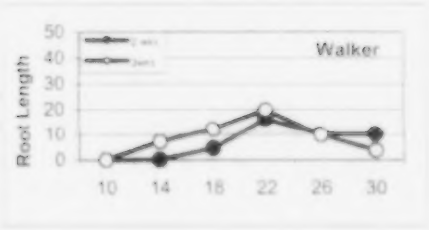
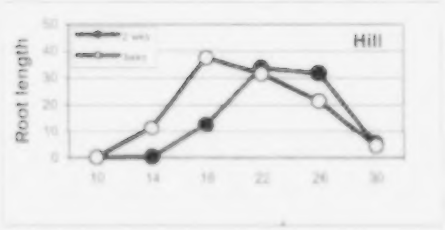
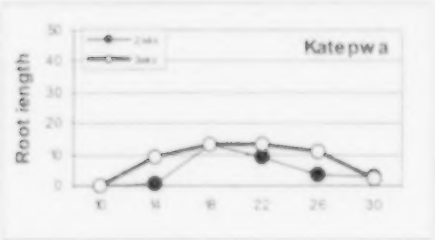
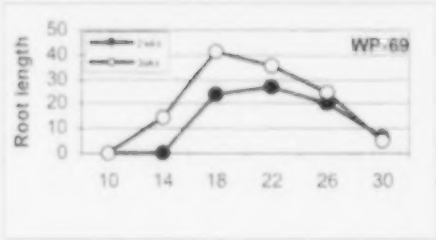


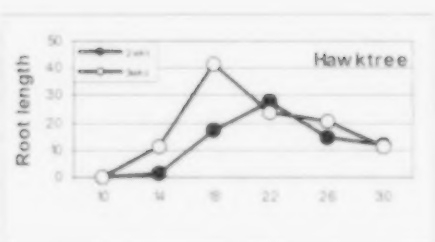
Figure 2: Average total length (cm) of roots on each cutting of various poplar clones after two and three weeks of growth at different temperatures (soil and air).

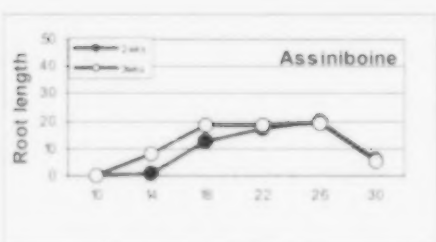

Root Length
Walker
50
40
30
20
10
0
10 14 18 22 26 30

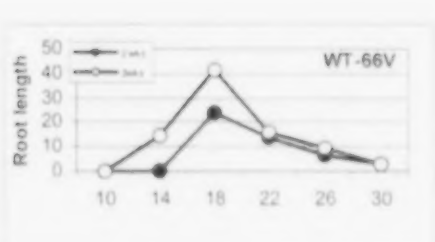

Root length
Hill
50
40
30
20
10
0
10 14 18 22 26 30


Root length
Katepwa
50
40
30
20
10
0
10 14 18 22 26 30


Root length
WP-69
50
40
30
20
10
0
10 14 18 22 26 30


Root length
Hawktree
50
40
30
20
10
0
10 14 18 22 26 30


Root length
Assiniboine
50
40
30
20
10
0
10 14 18 22 26 30


Root length
WT-66V
50
40
30
20
10
0
10 14 18 22 26 30

2.4.3 Evaluation of Weed Management Techniques

2.4.3.1 Registration of Herbicides for Hybrid Poplar

Introduction

Growth rates of hybrid poplars increase significantly when provided with a competition free environment. Weeds like Canada thistle (*Cirsium arvense [L.] Scop.*), perennial sow thistle (*Sonchus arvensis*), wild buckwheat (Polygonum convolulus), common purslane (Portulaca oleracea), redroot pigweed (Amaranthus retroflexus), quack grass (*Agropyron repens*[L.] Beauv.), wild oats (*Avena fatua L.*) and others and agronomic species of wheat, barley, oats clover and alfalfa for example, can significantly affect the survival and growth rate of hybrid poplar. Controlling weed vegetation within the tree row either by hand or by mechanical means has proven to be costly and time consuming. The availability of herbicide products for controlling the above weeds and promoting the growth of poplar are limited. The objective of the project is to determine the phytotoxicity of Lontrel (clopyralid) and Assure II (quizalofop-p-ethyl) applied over actively growing hybrid poplar clones and Goal (oxyfluorofen) applied as a pre-emergent in spring and fall. Data collected will be used to support minor use registration for Lontrel, Assure II and Goal for use in hybrid poplar plantations.

Methods

Hybrid poplar clones used in the project were Walker, Hill, Assiniboine and Katepwa. The plots were arranged in a Split Plot design replicated four times. The main plots were the herbicide treatments with the sub-plots consisting of the clone/stock type. Five plants of each poplar clone/stock type were planted in each plot, giving a total of 30 plants per plot. The plants were spaced 50 centimetres apart within the row, giving a plot length of 15 metres. Two metre buffers were left between plots. Two stock types, bare root and hot-lifted rooted plugs, were used for Walker and Assiniboine. Katepwa and Hill were bare root only. The study included eight herbicide treatments and a weed free check Assure II (96g/L EC) and Lontrel (360g/L SN) was applied post-emergent in mid July, when the trees were leafed out and actively growing. Goal (240 g/L EC) was applied as a pre-emergent when trees were dormant. The study was located in field K8 of the AAFC-PFRA Shelterbelt Centre, 11-18-13 W2, RM of Indian Head #156. The soil in the planting site is a clay loam. The planting site was tilled, including deep tillage to loosen the soil, in preparation for planting. Leaf development was assessed, new growth and the overall condition of the poplar plants was recorded.

Table: 1

Treatment	Product Name	PCP Reg. No.*	Application Rate per Hectare	
			product	active ingredient
weed free check				
oxyfluorfen (spring)	Goal 2XL	24913	4.17 litres	1.0 kg
oxyfluorfen (spring	Goal 2XL	24913	8.33 litres	2.0 kg
quizalofop-p-ethyl plus Sure-Mix adjuvant at 0.5%	Assure II	25462	300 mL	0.7 kg
quizalofop-p-ethyl plus Sure-Mix adjuvant at 0.5%	Assure II	25462	600 mL	0.14 kg
clopyralid	Lontrel 360	23545	340 mL	0.3 kg
clopyralid	Lontrel 360	23545	680 mL	0.6 kg

* Pest Control Products registration number.

Results

It should be noted that the hot-lift plants (of both Walker and Assiniboine) performed very poorly, even in untreated plots. None of the herbicide treatments reduced the amount of leaf development which occurred, except for a slight reduction for clopyralid on hot-lift Walker poplar. Walker poplar (dormant lifted) displayed leaf cupping at the 2X rate of clopyralid application. New growth, on the three main branches of each plant, was not reduced by any of the herbicide treatments. Data is being supplied to the Pest Management Review Agency for consideration of User Requested Minor Use Label Expansion (URMULE)

2.4.3.2 Weed Management Intensity Study

Introduction

Poplar farming involves intensive management practices more similar to agriculture than forestry. Vegetation control is a key management issue in poplar farming as agricultural soils have large weed seed banks that are released when the land is cultivated and taken out of cereal or forage production. Silviculture research has shown rapid initial growth responses of seedlings to reduced vegetative competition, however there is limited information on the duration of weed management required following planting.

The objectives of this study are to: 1) determine the influence of weed control intensities on growth of two hybrid poplars; 2) determine if poplar clones show differences in photosynthesis and stomatal conductance under various weed control intensities; 3) determine the effect of varying weed control intensities on nutrient status of hybrid poplar; 4) study the changes in weed ecology under varying weed control intensities.

Methods

Site Description: The study site is located in northwest Saskatchewan near Meadow Lake. Soils are classified as loam, with a pH of 6.5. The site had previously been in alfalfa seed production.

Study Design: The study includes the following variables: hybrid poplar clone and years of weed control, in a 2 x 4 randomized complete block design. Spacing for the study is 3.6 meters between rows and 2.4 meters within rows. Each treatment combination was replicated three times. The two clones evaluated are *P. x Hill* and and *P. x Walker*. Weed control level treatments include no weed control and complete weed control. Each treatment plot contains 49 trees.

***Tree planting and Weed Control*:** Prior to planting in 2002, the site had been spayed with glyphosate (May, 2002) and disced two times. The poplar clones (1-0 rooted cuttings) were planted in June 2002 using a mechanical tree planter. During the growing season, between row weeds were controlled by tillage in year one and two and application of glyphosate as required in year three and four. In-row weeds were controlled by a spot spraying with glyphosate.

Measurements: Nine trees in the centre of each plot are measured at the end of each growing season for height, and groundline diameter. Soil moisture was recorded weekly at 15, 30 and 50 cm depths using a Delta-T Profile Probe PR1. Net photosynthesis and stomatal conductance of nine trees per treatment plot were measured at mid crown using a ADC-LCPro gas exchange System. Leaf samples were collected for complete nutrient analysis and carbon isotope discrimination.

Results

Soil Moisture: Rainfall was abundant and well distributed throughout the 2004 growing period. Soil moisture increased with soil profile depth for both weeded and unweeded treatments (Figure 1). Soil moisture content for the weeded treatments were always greater than that for unweeded treatments for the 30 and 50 cm soil depth, but was similar at the 15 cm depth. We didn't compare rooting depth of trees in weeded and unweeded plots, however it is possible that larger, weeded trees have better access to moisture found in deeper portions of the soil profile.

Figure 1: Soil moisture at three depths in weeded and un-weeded plots

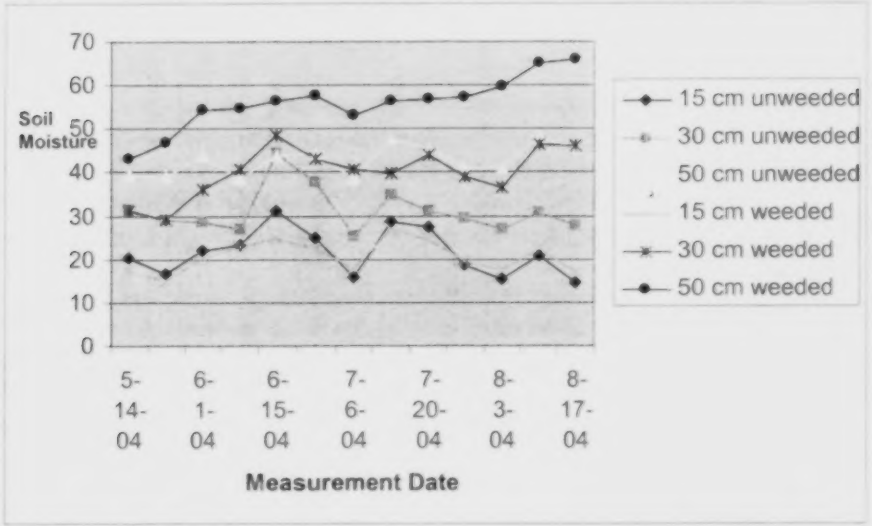


Figure 2: Interaction Between Clone and Weed Control Intensity on Four Year Tree Survival

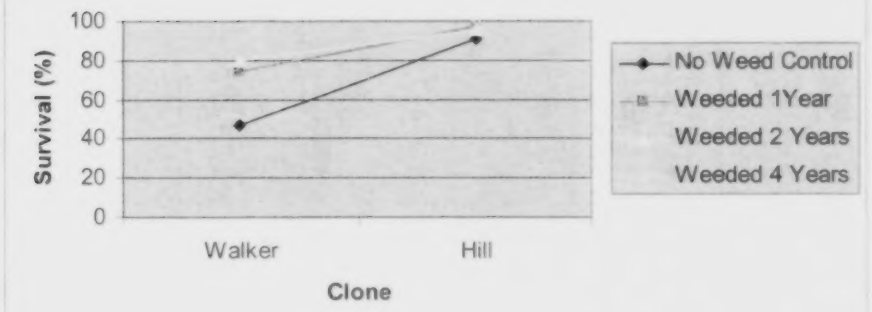
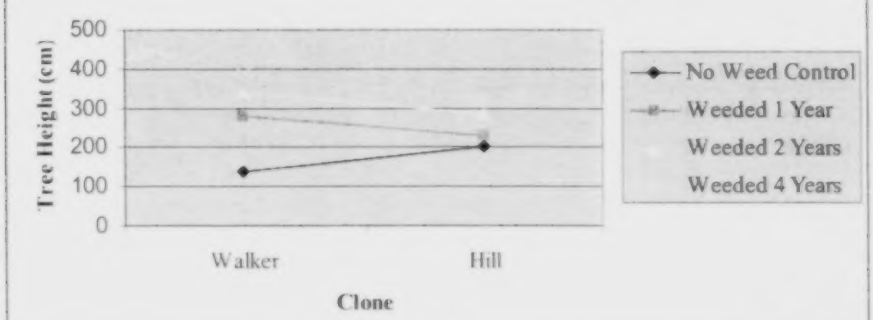


Figure 3: Interaction Between Clone and Weed Control Intensity on Four Year Height Growth



Tree Survival and Growth: Weed control had no impact on survival of Hill poplar (all treatments had over 90% survival, however for Walker absence of weed control decreased tree survival to less than 50% (Figure 2). Height and groundline diameter reductions were much greater when *P. x* 'Walker' was in non-weeded plots (2.8x increase in height in weeded plots). The height of Hill trees was relatively less affected by no weed control (1.6x increase in height). Similar trends were evident for groundline trunk diameter. Once again, in the absence of weed control stem diameters were significantly smaller regardless of poplar clone. Overall when weeds were controlled growth of Walker was superior to Hill poplar (Figure 3)During the first growing season weed competition had no significant effect on tree growth. However, during 2003 and 2004 weeds had established themselves such that weed competition had significant effects on poplar growth. Tree height (Figure 4) and root collar diameter (Figure 5) during the 2005 growing season were negatively related to weed competition. Height of *P. x* 'Hill' and *P. x* 'Walker' increased steadily during the 2005 growing season in the weeded plots. Growth of *P. x* 'Walker' trees weeded for two years and weed invasion allowed in the third year was not affected but re-invasion negatively impacted growth of *P. x* 'Hill'.

Figure 4: MLA Weed Management
Yearly Mean Height by Treatment

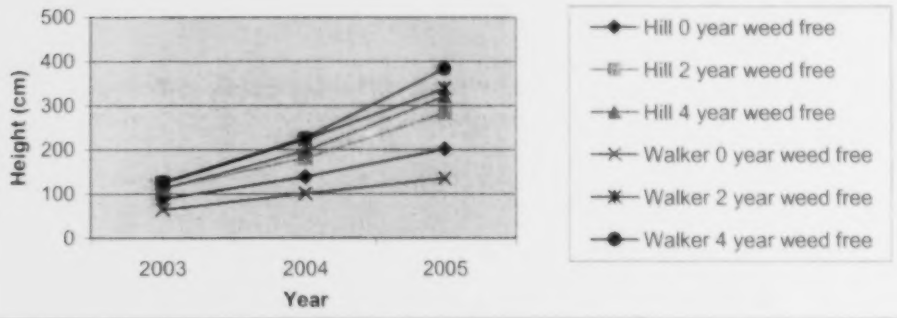
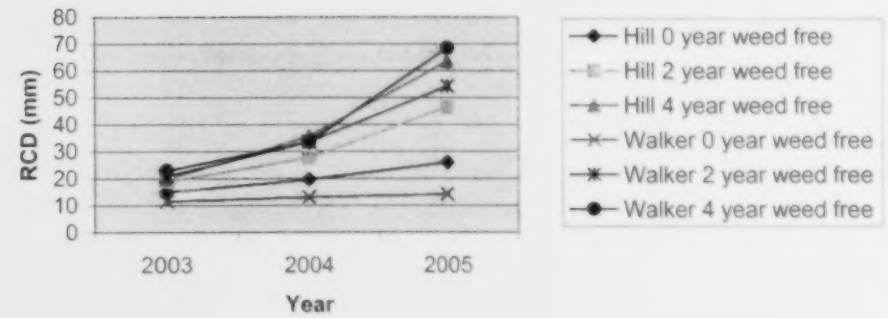


Figure 5: MLA Weed Management
Yearly Mean RCD by Treatment



Weed Biomass: The most commonly found weeds were perennials such as grass species, alfalfa and dandelions. The predominate annual weeds were narrow leaf hawk's-beard, yarrow, fleabane and wild oats. Total weed biomass remained unchanged in plots that had never been weeded whereas weeds populations in plots that were kept weed-free for two years were rapidly vegetated with weed species (Figure 6). In 2005, the weed biomass harvested from non-weeded plots was 1235 g/m^2 compared to over 1500 g/m^2 for plots

that had been allowed to re-vegetate with weeds after two years of being kept weed free. By 2005 weeds in non-weeded plots were nearly 100% perennial species (Figure 7).

Figure 6: Total Weed Biomass for 0 and 2 Years of Weed Control

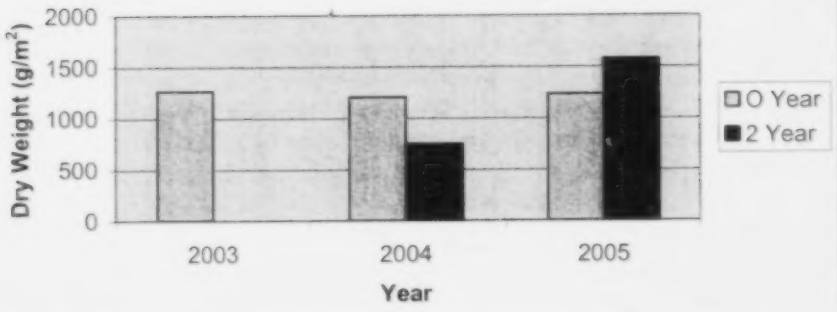
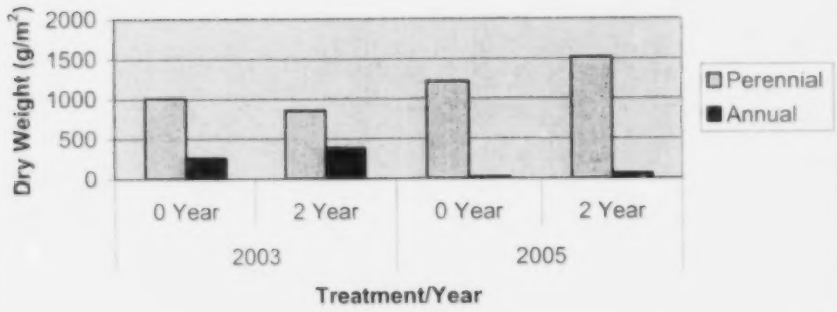


Figure 7: Weed Biomass - Annual vs. Perennial for 0 and2 Years of Weed Control



Foliar Nitrogen, Stomatal Conductance, Photosynthesis and Carbon Isotope Discrimination: There were significant differences in foliar N, δ13C values and photosynthetic rates among the weed treatments and between the two clones (Figures. 8, 9, 10). Plants growing with no weed control had the lowest leaf N while those with 4 years of weed control had the highest leaf N (Figure 8). The control plants had much lower foliar δ13C than plants from either 2 or 4-year weed control treatments (Figure. 9). Differences in δ13C values could result from changes in stomatal conductance (gs), photosynthetic rate (Figure 10) or a combination of both. The differences seen here are the result of higher photosynthetic rates in plants from the weeded plots because of the higher foliar N levels (Figure 8) rather than reduced gs (Figure. 11). The controls actually had slightly lower gs, yet much lower δ13C values. Moreover, the soil moisture data shows that there were no differences in soil moisture levels among the different treatments (Figure 1).

Figure 8 : Total leaf nitrogen in Hill and Walker poplar from the different weed control treatments.

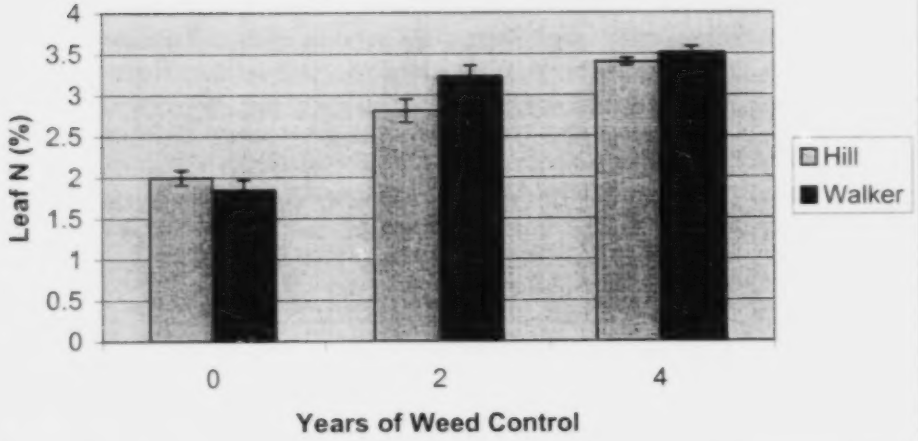


Figure 9: Leaf Carbon Isotope Discriminations in Hill and Walker poplar from the different weed control treatments.

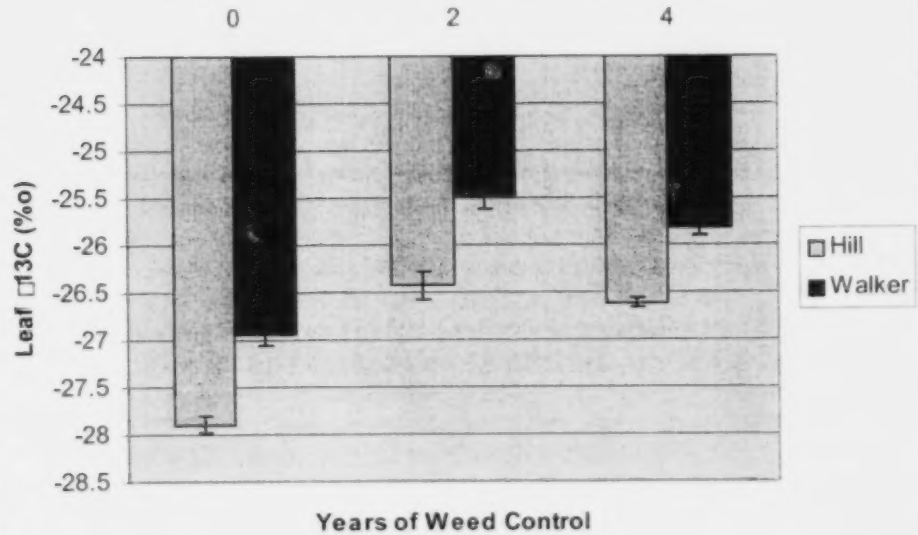


Figure 10: Net Photosynthesis in Hill and Walker poplar from the different weed control treatments.

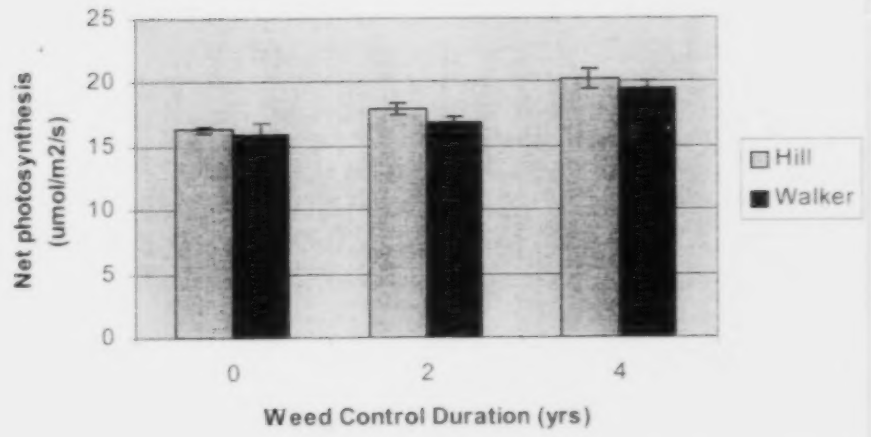
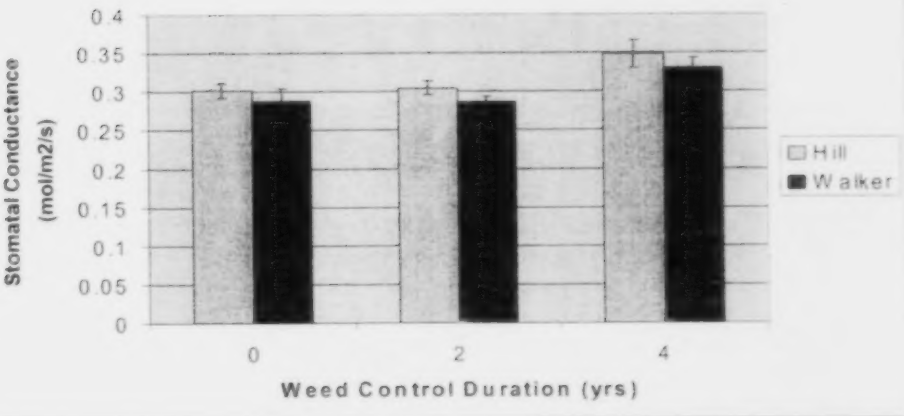


Figure 11: Stomatal conductance in Hill and Walker poplar from the different weed control treatments.



Conclusion

Control of competing vegetation is essential for successful poplar farming. *P. x* 'Walker' and *P. x* 'Hill' are significantly impacted by weed competition. This study has shown that controlling weeds during the first years following planting positively influences poplar growth. *P. x* 'Walker' appears to be more sensitive to weed competition than *P.* x 'Hill' and significant growth reductions can be expected when weeds are not controlled for both clones. This study suggests that early growth of poplar is negatively influenced by weed competition for nutrients rather than soil moisture. The study also showed that two years of weed control with *P.* x 'Walker' has some carryover of benefits to the next year if weed control has been discontinued. This trend was not as pronounced with *P.* x 'Hill'.

2.4.3.3 Effects of Weed Control Method on Hybrid Poplar

Introduction

Mulching has been long recognized as a beneficial practice in agronomic systems, where it often enhances growth and yield of annual and perennial crops. This enhancement has been attributed to the reduction of vegetative competition in the rooting zone and increases in the availability of key soil resources such as nitrogen and water. Mulching has also been shown to increase early root growth and nutrient uptake.

Study objectives are: To analyze any differences in establishment and growth between four poplar clones due to weed competition; Quantify impacts of different combinations of in and between row weed management on growth of four poplar clones. To determine the effect of plastic mulch on tree growth, as well as the effects of mulch on physical and chemical soil properties.

Methods

The test was established in May, 2004 at the ML-B project site. The study was arranged in a split plot design with three in-row, three between row weed control treatments and 4 poplar clone (P. x 'Hill', P. x 'Assiniboine', P. x 'Walker', P. x 'WP-69') subplots within each split (Appendix 9.2.1.1). Each plot contains five trees of the same clone. Spacing was 2.5 meters in-row and 3.5 meters between rows.

In-row weed control treatments are 1. Plastic mulch; 2. Chemical - Glyphosate spot sprayed; 3. No weed control. Between-row weed control treatments are: 1. Tillage (10-15cm deep); 2. Chem-Fallow using glyphosate applied with Enviromist sprayer; and 3. No weed control. At the end of the second growing season tree height and groundline diameter of each tree was measured. Analysis of variance were done to determine the influence of weed control method on poplar growth.

Results

In general, all clones had best growth when plastic was used for in-row weed control. In-row weed control with glyphosate did not differ significantly from no in-row weed control. The reason for this is attributed to spray drift from in-row application of glyphosate which had a negative impact on tree growth. The interaction between in-row and between row weed control method was statistically significant. Between-row control method had no impact on growth of trees when in-row weeds were controlled with glyphosate or not controlled. However for the plastic in-row treatment, between-row weed control significantly increased poplar growth.

Figure 1: Interaction Between In-Row and Between-Row Weed Control and Hill Poplar Growth

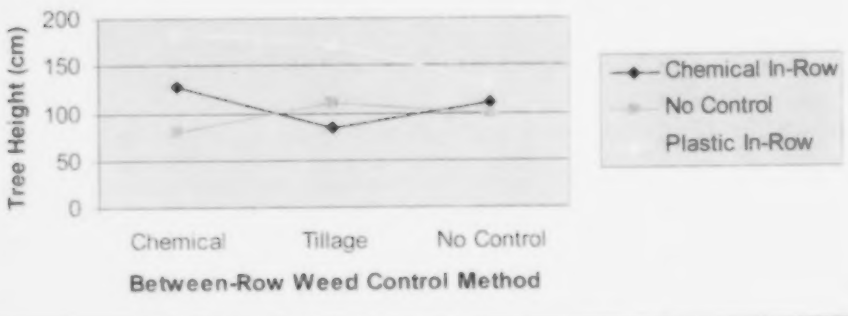


Figure 2: Interaction Between In-Row and Between-Row Weed Contol Method for Walker Poplar

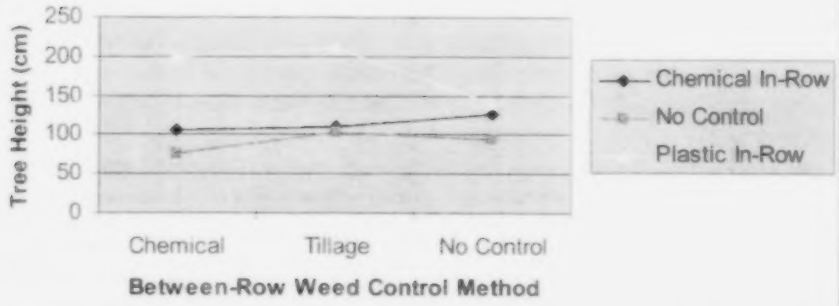
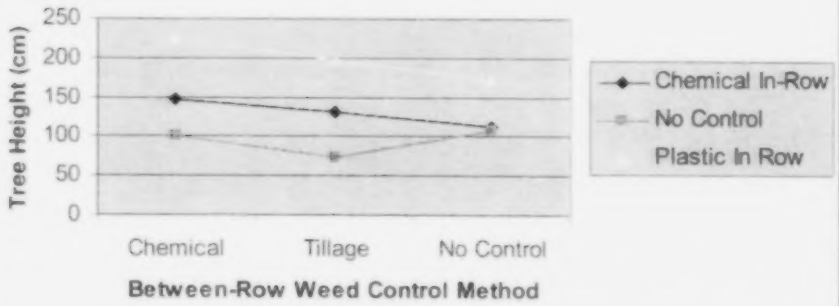


Figure 3: Interaction Between In-Row and Between-Row Weed Control Method for WP-69 Poplar



Conclusion

In view of these results, it is apparent that weed control method has an influence on tree growth. Plastic mulch offers distinct advantages relative to ongoing weed control requirements and growth of poplar. The use of herbicides such as glyphosate is effective however there are risks associated with spray drift damaging trees. The use of plastic, however does not substitute for the control of weeds between row. For optimal growth both between-row and in-row weed control is necessary.

2.5 Hybrid Poplar Clone Evaluation and Recommendations

Poplar refers to any trees in the genus *Populus*. Poplars are part of the botanical family known as *Salicaceae*, which also contains their close relatives, the willows. The poplars include over 30 tree species distributed worldwide. Several species of poplars are common in the prairies. Many of the poplars used for poplar farming are hybrids that were developed breeding programs that used both native and introduced poplar species.

Table:1

Native Populus Species in the Canadian Prairies			
Section	***Species***	***Common Name***	***General distribution***
Aigerios	*P. deltoides*	Eastern Cottonwood	Southern Prairies
Leucoides	*P. grandidentata*	Bigtooth Aspen	Eastern Manitoba
	P. tremuloides	Trembling Aspen	Across Prairies
Tacamahaca	*P. angustifolia*	Narrowleaf Cottonwood	Western Alberta
	P. balsamifera	Balsam Poplar	Across Prairies
	P. trichocarpa	Black Cottonwood	Western Alberta

What is a Hybrid Poplar?

A "hybrid" is produced when pollen of one poplar species is used to fertilize flowers of another species. For centuries, plant breeders have created hybrids of many crop and ornamental plants to improve both yield and appearance. Tree breeders choose parent trees that have particularly desirable characteristics. For example a common poplar hybrid used in North America is an interspecific crosses between the species deltoides and nigra (DN). Seedlings that result from these crosses may exhibit unique combinations of parental traits and "hybrid vigor" that is characterized by enhanced growth rate. Performance of new poplar hybrids is evaluated in field trials from which the best individuals can be selected for further use.

What is a Poplar Clone?

A poplar "clone" is a group of genetically identical plants that result from vegetative reproduction of a single tree (that is, without production of flowers or seed). Most poplars are "cloned" by producing "cuttings". These are segments, often 20 - 30 cm long, cut from young dormant stems or branches of the selected tree. When planted under proper conditions, these cuttings will spontaneously develop roots and shoots and rapidly grow into new trees. This process can be repeated again and again, allowing an unlimited number of copies of the same tree to be made. Because they are genetically identical, all members of the clone will be similar in rate of growth, form, pest resistance, and wood properties. Thus, superior clones can be selected and propagated for establishment of highly productive plantations. Clones are designated by unique names eg.'Walker' The use of letter and number combinations eg. 'WP-69' should be as short term and only used for experimental clones not yet released or commercialized. Incorrect identification of poplar clones is a problem, fortunately the advent of DNA fingerprinting will help to alleviate some of these problems.

2.5.1 Low Temperature Hardiness of Poplar Clones

Introduction

Hybrid poplars are commonly used for shelterbelts and other plantings in the Prairies. The Shelterbelt Centre has an active breeding program for developing new and hardy clones for the Prairies. A major factor determining the performance of hybrid poplars is their ability to survive our cold winters. Most of winter damage to poplars actually occurs in fall and spring and not in winter. Poplars are at the highest risk of damage from sudden cold temperatures in early fall and in early spring. Thus, the ability of poplars to withstand winter damage depends mainly on how quickly they become cold hardy in fall and how resistant they are to losing their hardiness in spring.

Methods

The objective of this study was to determine the patterns of 21 clones of hybrid poplar as they come out of dormancy (de-acclimation) in early spring and as they into dormancy (acclimation) in fall, using our newly established cold hardiness testing facility. Results of the study was from testing conducted during the spring and fall of 2003. Samples for testing were collected from hybrid poplar stooling beds located at the Shelterbelt Centre. Samples were collected weekly during the spring (mid March 17 to the end of April) to determine de-acclimation and in the fall (early September to late November) to determine acclimation. Each week, samples were collected, prepared and tested for ten minutes at various temperatures. Samples were then analysed to determine the lethal temperature to kill 50 precent of the sample material.

Results

All clones developed an extremely high degree of low temperature tolerance, but the dates of initiation, rates of development and patterns of de-acclimation or acclimation differed strongly among the clones. Three general patterns of de-acclimation were observed in the spring: a very early group which were unable to re-acclimate after exposure to low temperatures (Prairie Sky, DN-34 and Assiniboine); an intermediate group which were able to re-acclimate quickly whenever low temperatures occurred (Walker) and a very late group which deacclimated only when risks of low temperatures were minimal (Northwest, Tristis, Katepwa, Brooks #2, WP-69 and Hill). Three general patterns of acclimation were also observed in the fall: a very early initiation (without much exposure to low temperatures) accompanied by an extremely fast rate of acclimation (Tristis, Brooks #2, Northwest and WP-69); a later initiation (after exposure to low temperatures) but accompanied by a fast rate (Hill, Walker, and Katepwa); and a late initiation (after exposure to low temperatures) but with a slow rate (DN-34, Prairie Sky and Assiniboine). The patterns of de-acclimation in spring did not necessarily correspond to the patterns of acclimation in fall, e.g., hybrids that de-acclimate late in spring did not necessarily acclimated early in fall. These results indicate that both spring and fall hardiness patterns are important for successful plantings of hybrid poplar clones. The identified patterns can help in identifying the stages at which the different clones can be most vulnerable and also help identify the cold hardiness zones to which the different clones are less likely to suffer winter damage. Table 1 shows the ranking of clones to vulnerability of low temperature injury.

Table 1: Vulnerability to Low Temperature Injury[1,2]

Clone[3]	*Fall*	*Spring*	*Overall*
1. Tristis	not vulnerable	not vulnerable	not vulnerable
2. WP-69V	not vulnerable	not vulnerable	not vulnerable
3. Brooks#6	not vulnerable	not vulnerable	not vulnerable
4. Manitou	not vulnerable	moderately vulnerable	not vulnerable
5. WT-5V	not vulnerable	moderately vulnerable	not vulnerable
6. Northwest	slightly vulnerable	not vulnerable	slightly vulnerable
7. Hill	slightly vulnerable	not vulnerable	slightly vulnerable
8. Escott 4	slightly vulnerable	not vulnerable	slightly vulnerable
9. OPW-183-86	slightly vulnerable	not vulnerable	slightly vulnerable
10. OPW-138-86	slightly vulnerable	moderately vulnerable	slightly vulnerable
11. WT-66V	slightly vulnerable	moderately vulnerable	slightly vulnerable
12. Katepwa	moderately vulnerable	not vulnerable	slightly vulnerable
13. CanAm	moderately vulnerable	moderately vulnerable	moderately vulnerable
14. WT-127	moderately vulnerable	moderately vulnerable	moderately vulnerable
15. Walker	moderately vulnerable	moderately vulnerable	moderately vulnerable
16. Assiniboine	moderately vulnerable	very vulnerable	moderately vulnerable
17. Max#5	very vulnerable	moderately vulnerable	very vulnerable
18. WP-86V	very vulnerable	moderately vulnerable	very vulnerable
19. DN34	very vulnerable	very vulnerable	very vulnerable
20. Prairie Sky	very vulnerable	very vulnerable	very vulnerable
21. Nigra	very vulnerable	very vulnerable?[3]	very vulnerable.

[1] The winter hardiness rankings here apply to juvenile material up to the age of about 6 years. Material from trees older than this was not determined. Experience indicates, however, that the risk of winter injury decreases significantly with maturity of the trees.

[2] Based on field observations over the years and the current climate patterns, the vulnerabilities translate approximately as follows: very vulnerable means the chances top dieback due to cold temperatures are about 6 in 10 years; moderately vulnerable would be 3 in 10 years; slightly vulnerable would be 1 in 10 years; and not vulnerable means there will be no injury to the trees in their lifetime.

[3] The numbers besides the clones correspond to their overall (fall and spring) cold hardiness rankings. Absolute mid-winter temperature hardiness was about the same for all the clones.

[4] This could not determined because the plants were killed in the fall.

2.5.2 Small Block Clone Trial

Introduction

This study was located at four sites with two sites near Meadow Lake one at Star City. The study includes 33 hybrid poplar clones that have been developed by the AAFC-PFRA and 16 hybrids developed elsewhere. The AAFC-PFRA poplar program at Indian Head is designed to develop *Populus* clones that are drought and cold hardy, pest resistant and fast growing. Since 1981 over 100 poplar clones have been identified for evaluation. There is limited information on the adaptability of AAFC-PFRA clones for use in plantation style poplar farms. Many clones have been developed in Europe and eastern North America over the years. These clones are currently used in poplar farming programs in eastern Canada and the midwest states of United States. The objective of the study is to determine adaptability and growth performance of the poplar clones developed y AAFC-PFRA compared with standard clones used in programs outside the prairie region.

Methods

The trials are set out in three replicated blocks of nine tree plots. Each plot is buffered by rows of Walker poplar. The Meadow Lake and Star City sites were established in 2002 using 1-0 rooted cuttings. Weed competition was controlled at each site using a combination of mechanical cultivation and herbicides.

The inside tree trees in all plots were designated as permanent sample trees from which all measurement and scoring was done. In 2005, survival, tree height, DBH (diameter breast height) was measured at all test sites. At Meadow Lake Site A (MLA) crown form and dieback were also measured. Die back was a visual estimate of the degree of dieback present in the tree's crown. Crown form was a visual rating of bole straightness and crown branching. In order to compare performance of clones, performance of each clone was compared to the test mean for each trait and expressed as a percentage. Data was combined to provide an overall performance score computed as:

$$\text{Score} = 600 + \text{Survival} + \text{Height} + 10x(\text{DBH}) - 5x(\text{Crown}) - 10x(\text{Dieback})$$

Results

The test sites had received below average rainfall in the first two growing seasons. These drought conditions significantly impacted early growth and growth rates only started to recover in 2004. In addition low temperature events in late September of 2002 and 2003 at the Meadow Lake sites resulted in significant dieback of some clones. The effects of the dieback are demonstrated in ranking of the clones. The clones exhibiting the best overall performance were, for the most part, those that had above average tolerance to low temperature injury and were developed in the AAFC-PFRA breeding program. WP-69, the top ranking clone, is derived from a hybrid cross made at AAFC-PFRA between P. xWalker x P. xpetrowskyana. Above average survival and growth and well below average low temperature dieback were its strengths. P. 71-W60 was ranked second and is an open-pollinated progeny of Walker. Its strengths are similar to WP-69 except for slightly higher dieback but better form. P. x14273 developed at the Morden Research Station from a cross between P. deltoides x P. nigra italica. This clone had excellent growth but had higher than average dieback. Performance scores of top clones, as well growth, dieback and form scores are shown in Table 1.

Table 1: Performance of top clones at Meadow Lake (MLA) clone trial

Clone	Background	Score	Height*	DBH*	Dieback*	Form*
WP-69	P. xWalker x P. xpetrowskyana	1040.8	143.7	188.3	82.2	106.2
71-W60	OP progeny of Walker	1040.8	143.3	187.1	98.0	79.5
P.14273	P deltoides x P. nigra italica	1039.6	142.2	179.3	115.9	104.2
71-66	OP progeny of Walker	1035.0	127.0	153.2	122.3	97.1
OPW 120H	OP progeny of Walker	1025.8	141.4	180.7	86.2	85.9
Brooks #1	P. deltoides x P. xpetrowskyana	1025.3	125.1	181.5	69.0	91.1
Prairie Sky	P deltoides x P. nigra italica	1009.1	121.0	130.4	110.3	97.9
WS-6-65	P. xWalker x P. xjackii Saskatchewan	1007.6	137.9	180.1	119.4	98.2
OPW-177H	OP progeny of Walker	1004.6	145.7	197.3	116.0	90.0
Tristis	Tacamahaca species	985.3	119.7	151.1	57.9	108.3
Walker	P. deltoides x P. xpetrowskyana	970.1	135.3	181.5	112.1	73.8
WT-127	P. xWalker x P. tristis	968.0	124.4	141.4	95.2	76.9
WS-151E	P. xWalker x P. euramericana Serotina de Selys	962.6	113.4	131.7	99.6	75.2
Katepwa	OP progeny of Walker	958.1	144.7	195.2	113.9	90.6
71-210	OP progeny of Walker	935.5	109.9	110.4	114.9	124.0

*** Data is presented is expressed as a percentage of plantation mean and are not absolute values**

Figure 1: Performance Scores of Poplar Clones at MLA

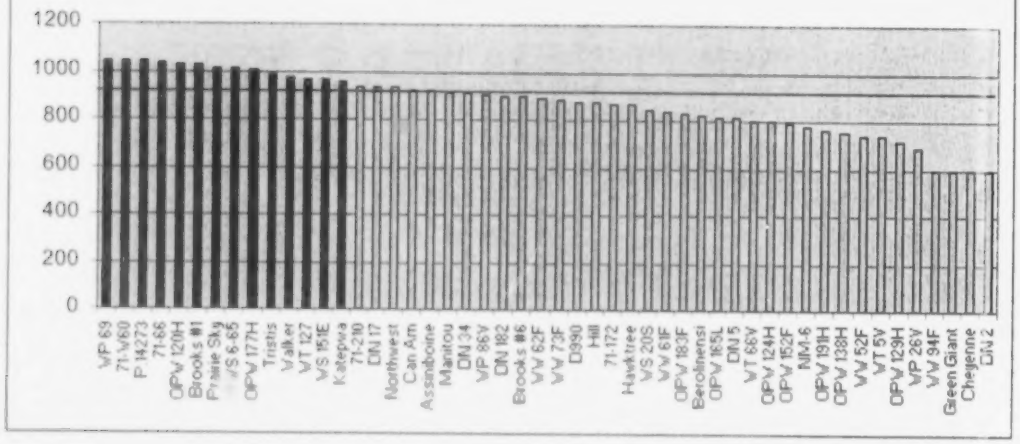


Figure 3a: Four Year Tree Height of Poplar Clones in Small Plot Trials

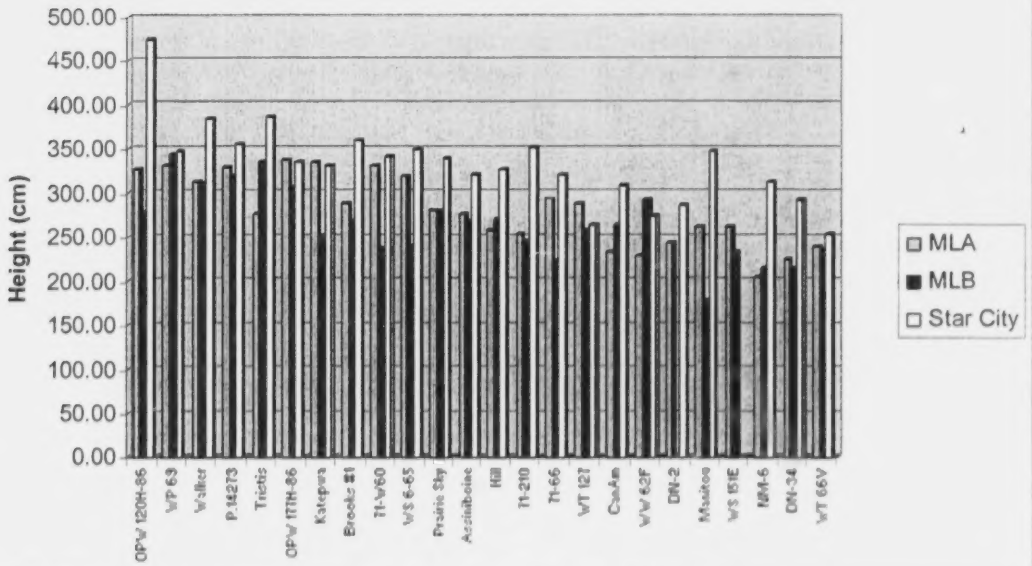
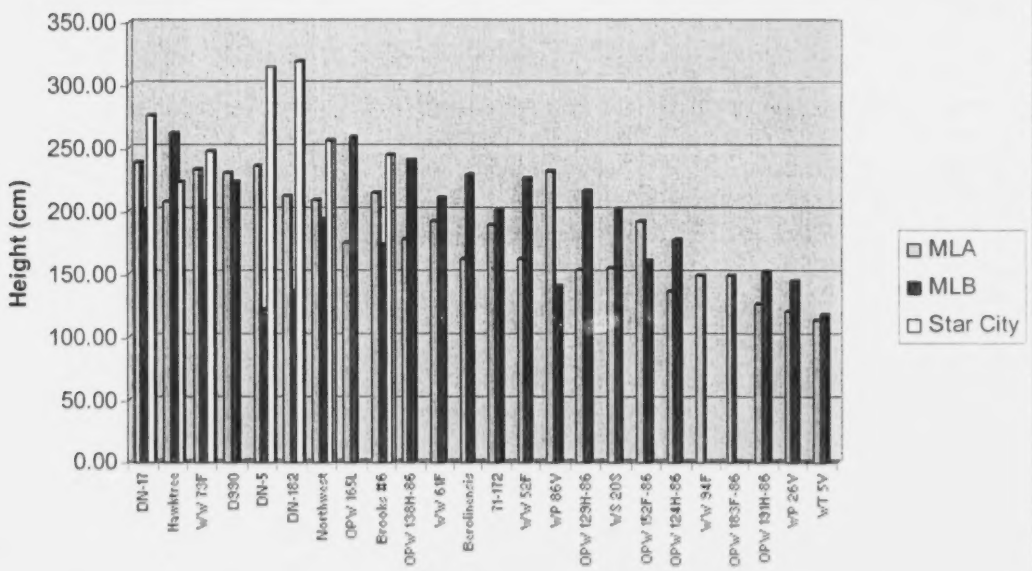


Figure 3b: Four Year Tree Height of Poplar Clones in Small Plot Trials



2.5.3 Large Block Clone Trial

Methods

The studies are situated at the Meadow Lake A, Meadow Lake B and Star City sites. The study includes 15 clones at the Meadow Lake A and Meadow Lake B sites and 12 clones at the Star City site. The poplar clones tested were predominately hybrid poplars from the breeding program at AAFC-PFRA Shelterbelt Centre in Indian Head. Most of these clones were developed for shelterbelt planting and there is limited knowledge of their performance in plantations.

The tests were established on former agricultural land that had been in annual crop (Star City) or forage production (MLA & MLB). All trees were planted as 1-year-old rooted cuttings. The trial is set out in three replicated blocks of 49 tree plots per clone. Tree spacing is 3.6 x 2.4 meters. Weeds were controlled for four years through a combination of cultivation, mowing and herbicides. Overall weed control was very good at all sites.

In 2005, tree height, DBH and a visual rating of low temperature dieback was recorded for 25 trees in the centre of each plot. The same trees were measured throughout the study in the fall of years two, three and four after planting. One tree per plot at each site was harvested and dried to determine total tree dry weight. Using the plantation mean overall score was calculated for each clone. The following formula was used to calculate the score:

$$\text{Score} = 600 + (\%\text{Height} + \%\text{DBH} + \%\text{Biomass}) - (\%\text{Dieback})$$

Results and Discussion

Overall mean clone tree height and DBH for all test sites is shown in Figure 1 and 2. Four year growth data suggests that WP-69, Assiniboine, Katepwa, tristis and Walker are most vigorous clones with above average growth rates compared to other clones in the test. Growth of Walker has improved significantly since 2003. When total biomass was considered the top clones were Tristis and WP-69 (Figure 3). When overall score was considered, two clones (WP-69 and WT-66V) were consistently among the top clones at all test sites. WP-69 was the top performing clone at all sites. Its main attributes are superior hardiness combined with growth and biomass accumulation.

Aboveground biomass was greatest for WP-69, Tristis and WT-66V (Figure 3). This data shows the potential of different clones for carbon sequestration. Although vary preliminary, the data suggests that clone selection and site can have can have a large impact on carbon sequestration opportunity (Figure 6).

Comparative annual growth trends of poplar clones according to project site are shown in Figures 7a-p. Tree growth varied between sites. The least productive site for most clones was Meadow Lake B. This site also had the highest incidence of winter injury in 2003. Overall, growth was best at Meadow Lake A followed by Star City. This data confirms that clone performance is related to site conditions. For example clone 71-210 ranked higher at MLB than it did at other sites suggesting that this clone is better adapted to poorer site conditions than other clones.

Hardiness was a major issue at all test sites. Dieback, especially in 2003 and 2004, significantly impacted vulnerable clones. The vulnerability to low temperature injury was a major factor reducing growth and overall score of lower ranked clones.

It must be emphasized that these results are preliminary and based largely on juvenile growth. Rankings could change significantly over time as trees mature and other factors such as disease susceptibility come into play. It is likely that clone ranking could change significantly over time as the trees mature.

Table 1: Ranking of poplar clones at test sites

Rank for Height (cm)		Rank for DBH (cm)		Rank for Biomass (kg/tree)		Rank for Dieback (% trees with dieback)		Rank for Score	
Star City									
Katepwa	368.8	Katepwa	3.75	WP 69	3.9	Northwest	13.6	WP-69	969
WP 69	338.8	WP 69	2.93	Katepwa	3.5	WP 69	30.1	Katepwa	909
Walker	328.3	Walker	2.73	Northwest	3.0	WT 66V	53.5	Northwest	875
WS 6-65	317.7	WT 66V	2.69	WT 66V	2.8	Brooks #6	61.1	WT 66V	874
WT 66V	308.9	WS 6-65	2.58	Walker	2.8	Brooks #1	63.2	Walker	828
71-210	294.6	71-210	2.10	WS 6-65	2.7	Hill	87.5	WS 6-65	815
CanAm	294.6	CanAm	2.03	71-210	2.1	Hawktree	90.3	71-210	755
Northwest	258.4	Hill	1.86	Hill	2.1	WS 6-65	90.9	Hill	740
Hill	256.9	Northwest	1.79	Hawktree	2.0	Walker	91.2	CanAm	728
Brooks #6	224.7	Brooks #6	1.51	Brooks #1	1.7	71-210	94.2	Brooks #6	714
Hawktree	217.1	Hawktree	1.18	CanAm	1.5	CanAm	95.2	Brooks #1	706
Brooks #1	198.3	Brooks #1	1.15	Brooks #6	1.2	Katepwa	98.6	Hawktree	688
Meadow Lake Site A (MLA)									
Katepwa	422.4	Katepwa	3.80	Tristis	4.9	Tristis	30.2	WP 69	951
WP 69	417.4	WP 69	3.72	WP 69	4.5	WP 69	39.7	Tristis	926
Walker	402.1	Walker	3.61	WT 66V	3.9	Brooks #6	73.1	Walker	863
Assiniboine	368.2	WT 66V	3.36	Walker	3.7	Northwest	83.6	WT 66V	836
71-210	363.1	WS 6-65	3.17	CanAm	3.5	Walker	86.4	Katepwa	833
WS 6-65	354.8	Tristis	3.00	Hill	3.4	Brooks #1	89.8	71-210	791
WT 66V	353.7	Assiniboine	2.94	71-210	3.1	WT 66V	95.5	WS 6-65	779
Tristis	335.9	71-210	2.85	Hawktree	3.1	Hawktree	95.5	CanAm	773
CanAm	331.3	Brooks #6	2.72	Katepwa	2.9	WS 6-65	100.0	Hill	773
Prairie Sky	316.7	Hill	2.54	Brooks #1	2.8	Prairie Sky	100.0	Assiniboine	767
Hill	314.2	Prairie Sky	2.39	Prairie Sky	2.5	Katepwa	100.0	Brooks #6	761
Brooks #6	307.3	Northwest	2.34	WS 6-65	2.5	Hill	100.0	Hawktree	752
Hawktree	296.7	CanAm	2.25	Assiniboine	2.3	CanAm	100.0	Prairie Sky	742
Northwest	284.0	Hawktree	2.20	Brooks #6	1.9	Assiniboine	100.0	Brooks #1	728
Brooks #1	274.1	Brooks #1	1.80	Northwest	1.8	71-210	100.0	Northwest	726
Meadow Lake Site B (MLB)									
WP 69	331.3	WP 69	2.54	WP 69	1.9	WP 69	22.9	WP 69	1033
71-210	261.7	Katepwa	1.71	71-210	1.7	Brooks #6	46.2	71-210	830
Walker	255.0	WS 6-65	1.67	WS 6-65	1.6	Brooks #1	63.6	OPW 177H	829
Katepwa	252.8	Walker	1.65	OPW 177H	1.6	WT 66V	65.6	WT 66V	827
WS 6-65	250.8	71-210	1.65	Hawktree	1.6	Northwest	75.6	WS 6-65	824
WT 66V	248.2	WT 66V	1.62	Northwest	1.3	OPW 177H	79.5	Hill	801
Hill	246.4	Hill	1.55	CanAm	1.3	Hill	88.6	Katepwa	787
OPW 177H	243.8	OPW 177H	1.47	Prairie Sky	1.3	Katepwa	90.0	Prairie Sky	785
Prairie Sky	242.3	Prairie Sky	1.40	Hill	1.3	Walker	90.6	Walker	778
Hawktree	203.2	Hawktree	1.08	WT 66V	1.2	Prairie Sky	92.6	Hawktree	763
CanAm	202.3	CanAm	1.06	Katepwa	1.0	Hawktree	93.5	Northwest	751
Brooks #6	190.5	Northwest	0.96	Walker	0.9	WS 6-65	97.7	Brooks #6	748
Brooks #1	186.5	Brooks #6	0.85	Brooks #6	0.9	71-210	98.2	CanAm	735
Northwest	181.1	Brooks #1	0.78	Brooks #1	0.7	CanAm	100.0	Brooks #1	709

Figure 1: Average four year height of poplar clones at project sites

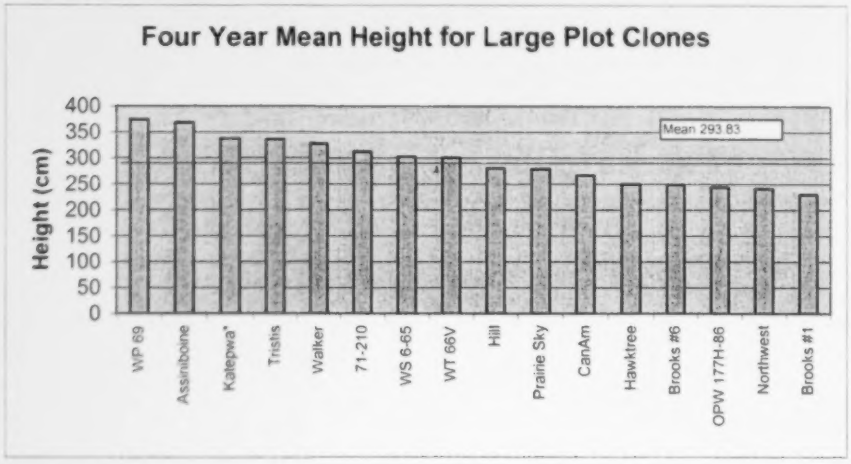


Figure 2: Average four year DBH of poplar clones at project sites.

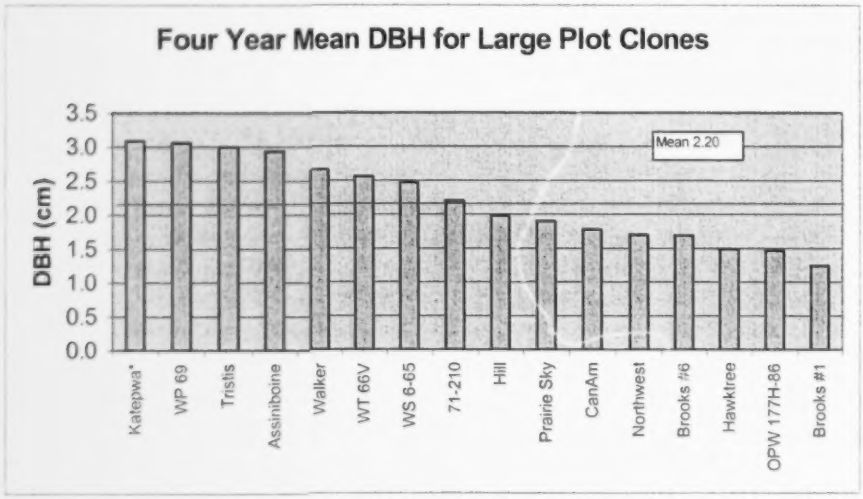


Figure 3: Average four year total aboveground biomass of poplar clones at project sites

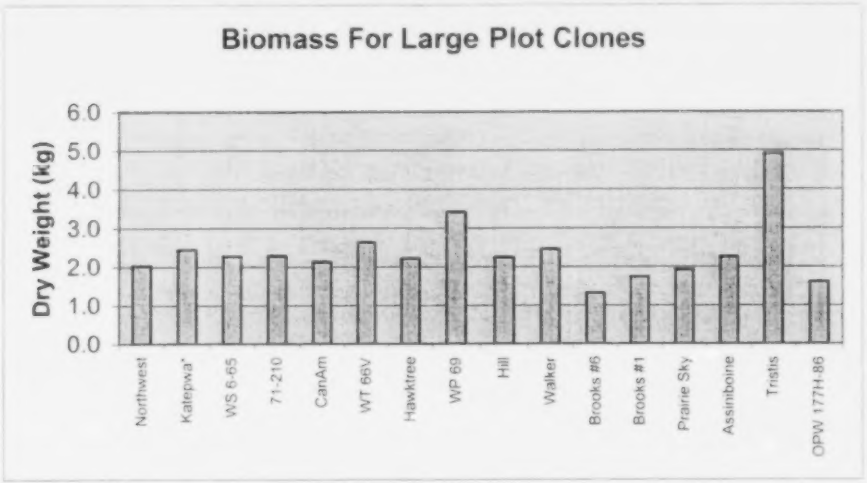


Figure 4: Average clone height at each project site

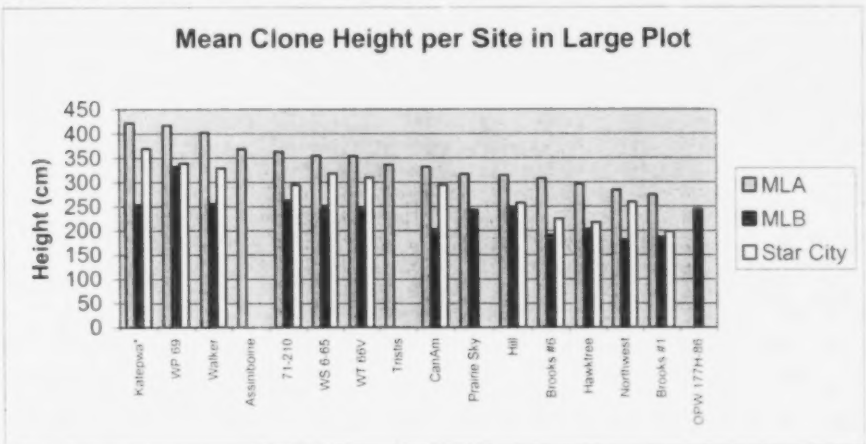


Figure 5: Average clone DBH at each project site

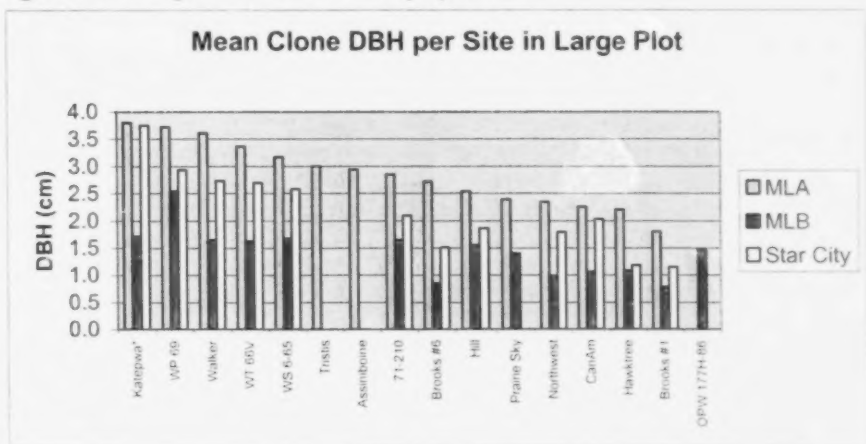


Figure 6: Average above ground biomass for clones at each project site

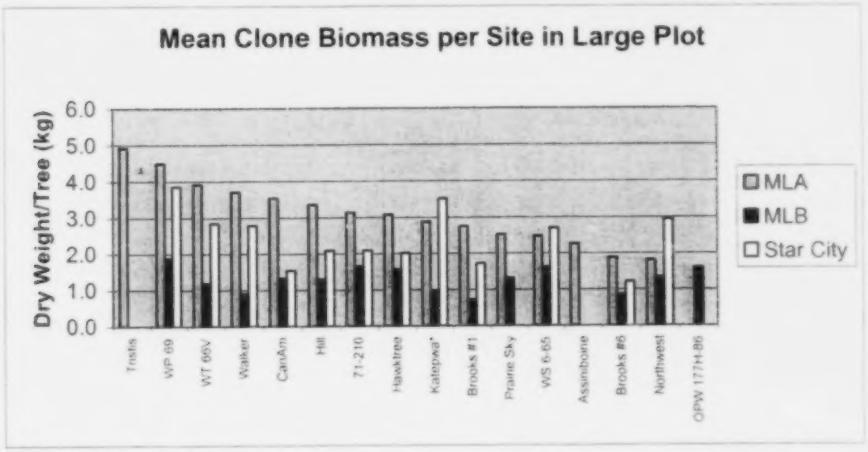
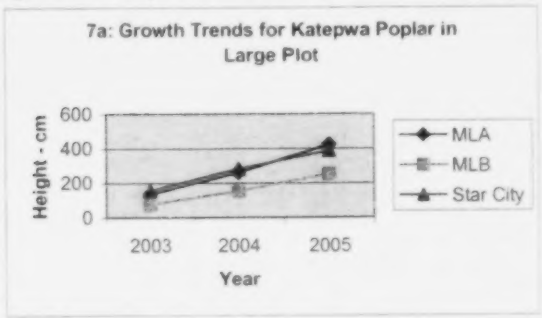
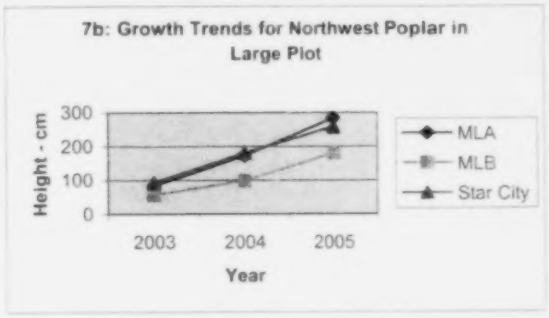
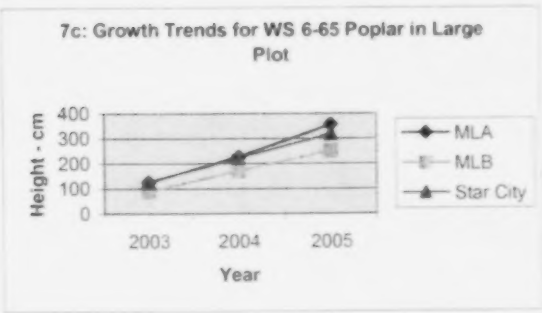
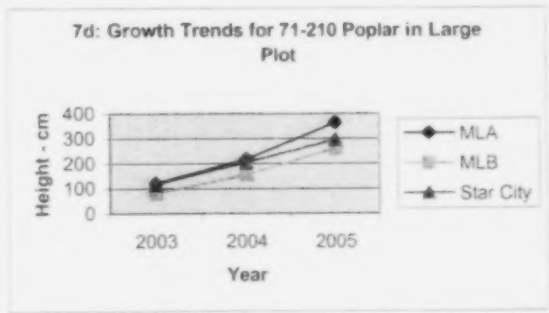


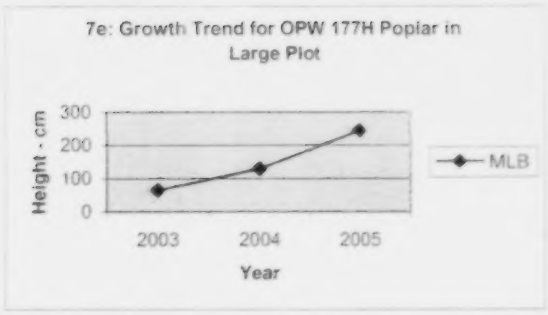
Figure 7: Comparative annual growth trends of poplar clones according to project site.

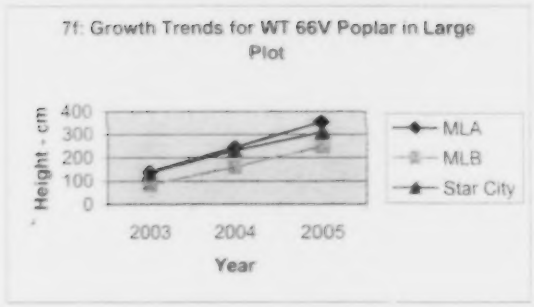


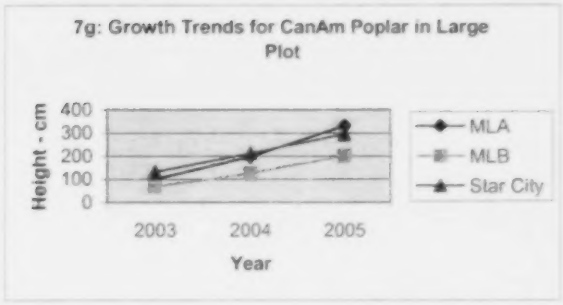


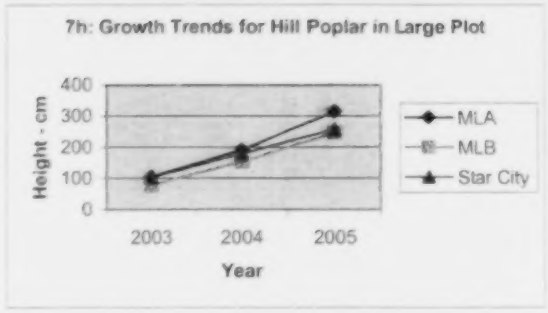


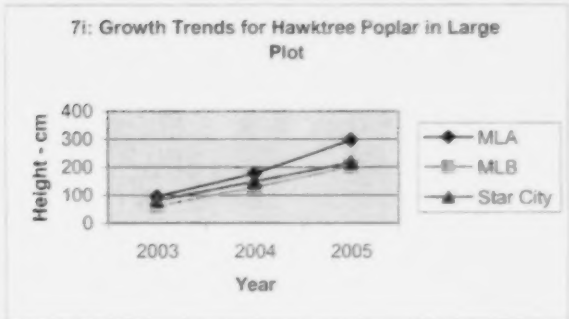


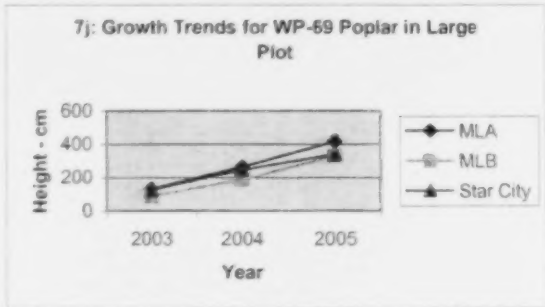

7e: Growth Trend for OPW 177H Poplar in Large Plot
Height - cm
300
200
100
0
2003
2004
2005
Year
MLB

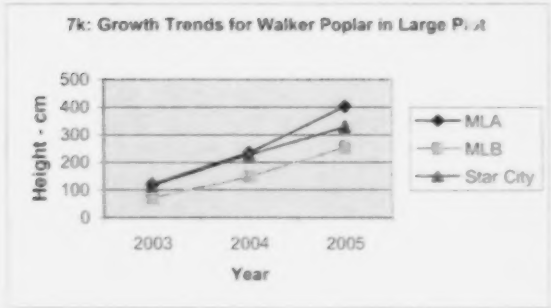

7f: Growth Trends for WT 66V Poplar in Large Plot
Height - cm
400
300
200
100
0
2003
2004
2005
Year
MLA
MLB
Star City

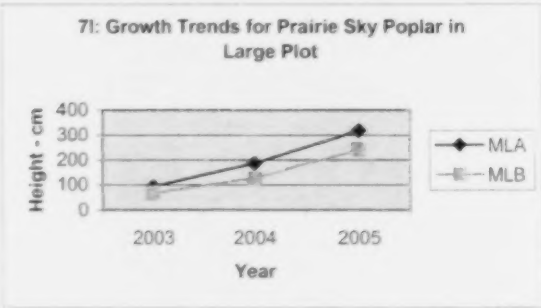

7g: Growth Trends for CanAm Poplar in Large Plot
Height - cm
400
300
200
100
0
2003
2004
2005
Year
MLA
MLB
Star City

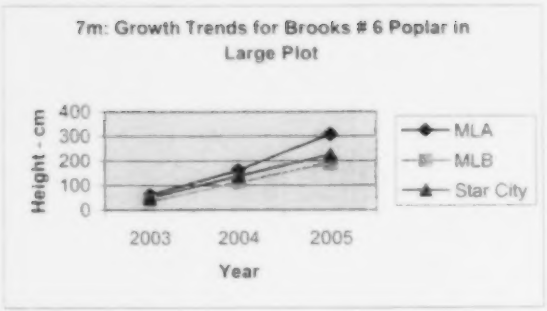

7h: Growth Trends for Hill Poplar in Large Plot
Height - cm
400
300
200
100
0
2003
2004
2005
Year
MLA
MLB
Star City

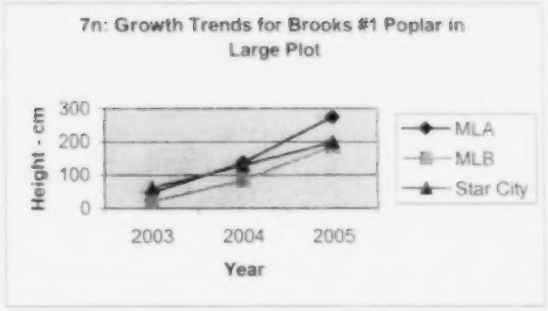

7i: Growth Trends for Hawktree Poplar in Large Plot
Height - cm
400
300
200
100
0
2003
2004
2005
Year
MLA
MLB
Star City

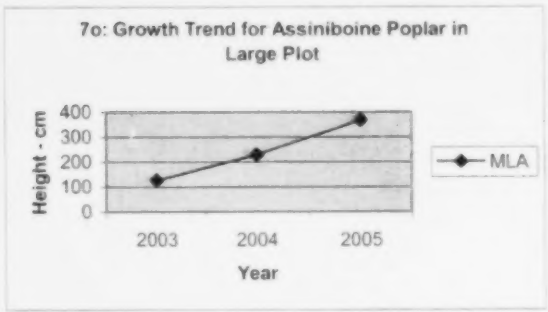

7j: Growth Trends for WP-69 Poplar in Large Plot
Height - cm
600
400
200
0
2003
2004
2005
Year
MLA
MLB
Star City

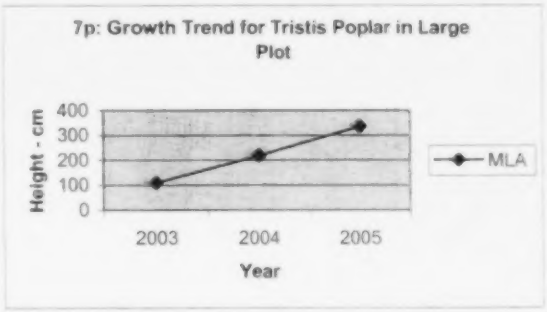

7k: Growth Trends for Walker Poplar in Large Plot
Height - cm
500
400
300
200
100
0
2003
2004
2005
Year
MLA
MLB
Star City


7l: Growth Trends for Prairie Sky Poplar in Large Plot
Height - cm
400
300
200
100
0
2003
2004
2005
Year
MLA
MLB









2.5.4 Poplar Clone Recommendations

The suitability of poplar clones tested in the project was reviewed. Information was obtained from test planting records, lab tests and field observations during the project. This information can be used to make decisions on poplar clone use. Information is grouped into four categories: Origin, Tree Characteristics, Stress Resistance and Nursery Production. This information can be found in the accompanying table.

Origin - This provides information on the ancestry of poplar clones.

Alternate Names - This section provides alternative names that have been used for the clone.

Tree Characteristics - This category includes information on growth rate, tree form and sex. **Growth rate** has been divided into two categories: 1 - **Fast** (>1.0 m/yr), 2 - **Moderate** (0.8-1.0 m/year). **Tree form** provides an indication of crown form. Upright form indicates that the tree has a narrow crown with branch angles $< 45^{O}$. Semi-right is slightly more spreading than upright with branch angles approaching 45^{O}; Wide form indicates a wide crown with heavy branching and branch $>45^{O}$. Sex refers to the presence of male or female flowers.

Hardiness - This category provides an indication of a clone to withstand low temperatures. **Vulnerability to low temperature damage** has been divided into four ratings 1- **not vulnerable** means the clone rapidly attains maximum cold hardiness and low temperature damage is extremely unlikely; 2 – **slightly vulnerable** means that clones are very rarely affected by low temperatures; 3 - **moderately vulnerable** indicates that clones are periodically susceptible to low temperature damage; 4 – **very vulnerable** - clones have a high risk of yearly low temperature damage.

Disease - Septoria stem canker is one of the most common and most serious canker diseases found on poplars. The ratings are: 1- **resistant**, 2- **moderately susceptible**, 3 - **highly susceptible**.

Recommendations

The review of data provided by the project shows that several clones have marginal performance and their use in Saskatchewan is not recommended. The main clones in question originate from outside the prairie region and have significant limitations for deployment in Saskatchewan mainly the result of vulnerability to low temperature damage. Table 1 describes key characteristics of clones that have been tested under Saskatchewan growing conditions. Photos of the poplars (Photos 1 -20) illustrate overall form of the clones

Table 1: Characteristics of Poplar Clones

Clone	Origin	Alternate Names	Tree Characteristics			Hardiness	Disease	Recommended clone
			Growth	Form	Sex			
Assiniboine	Open-pollinated Walker seedling	OPW-130L-86	2	1	Male	3	1	S,R,P
Berolinensis	laurifolia x nigra	Berlin	2	2	Male	2	2	NR
Brooks 6	deltoides x petrowskyana	Green Giant	2	1	Male	1	2	S,R,P,PF
CanAm	Open-pollinated Walker seedling		2	2	Female	3	1	S,R,P
DN-34	deltoides x nigra	Imperial	1	2	Male	4	1	NR
DN-182	deltoides x nigra	Raverdeau	1	1	Male	4	1	NR
Griffin	deltoides x petrowskyana	Brooks 1	2	1	Male	2	3	NR
Hawktree	Open-pollinated Walker seedling		2	2	Male	2	1	S,R,P
Hill	deltoides x petrowskyana	FNS 44-55	2	2	Female	2	2	S,R,P,PF
Katepwa	Open-pollinated Walker seedling	OPW-180H-86	1	1	Male	2	2	S,R,P,PF
Manitou	Open-pollinated Walker seedling	OPW-34L-86	2	3	Male	1	3	NR
NM-6	nigra x maximowiczii	Max-5	1	1	Male	4	1	NR
Northwest	balsamifera x deltoides		2	3	Male	2	2	S,R,P,PF
Prairie Sky	deltoides x nigra italica		1	1	Male	3	1	NR
Russian	Laurifolia x nigra	petrowskyana	2	2	Male	1	3	NR
Tristis SBC	P. tristis (Tacamahaca species)		2	3	Male	1	1	S,R,P
Walker	deltoides x petrowskyana	FNS 44-52	1	1	Female	3	2	S,R,P,PF
WP-69	Walker x petrowkyana		1	2	Male	1	1	S,R,P,PF

Growth Rate: 1 - Fast
2 - Moderate

Disease Rating: 1 - Resistant
2 - Susceptible
3 - Highly susceptible

Form: 1 - Straight/narrow crown
2 – Moderate wide crown,
3- wide spreading crown

Hardiness Ratings: 1 - not vulnerable
2 - slightly vulnerable

Recommendation: S - Shelterbelt P - Phytoremediation
R - Riparian PF - Poplar Farming
NR- Not Recommended

Photo 1: Assiniboine

Photo 2: Berolinensis

Photo3: Brooks #6

Photo 4: CanAm

Photo 5: DN-34

Photo 6: DN-182

Photo 7: Griffin

Photo 8: Hawktree

Photo 9: Hill

Photo 10: Hill (Mature)

Photo 11: Katepwa

Photo 12: Katepwa (Mature)

Photo 13: Manitou

Photo 14: NM-6

Photo 15; Northwest

Photo 16: Prairie Sky

Photo 17: Russian

Photo 18: Tristis

Photo 19: Walker

Photo 20: WP-69

2.6 The Response of Poplar Clones to Application of Liquid Swine Manure

Introduction

Swine production in Saskatchewan is, for the most part, concentrated in large facilities. Manure cannot be transported long distances, and as a result land application of effluent is close to its source. Intensive swine operations need to avoid negative environmental impacts such as leaching of nitrogen into groundwater and runoff into water bodies. Swine manure can provide a source of nutrients for fast-growing tree crops. Applying wastes present in manure to non-food crops such as trees safely disposes of the waste while reducing the danger of heavy metals, sometimes present in the manure, from entering the food chain.

Hybrid poplars are fast-growing trees that can take up large amounts of nutrients and water. Irrigation of a poplar stand can be part of an manure disposal solution. Poplars have advantages over other plant species because they transpire larger quantities of water, require a minimum amount of management after establishment, need few interruptions of treatment schedules, reduce the chance for food-chain transfers of heavy metals and other toxic chemicals contained in the effluent, produce larger amounts of biomass, and have long lifespans. The objective of this project is to evaluate the response of different poplar clones to applications of swine manure.

Methods

The study was established at Pasquia Pork Producers near Arborfield, Saskatchewan. In 2002, Eight hybrid poplar clones were planted in 200 tree plots replicated three times. Thirty-two 59 x 38 meter (200 tree) plots will be required. Tree spacing of 2.0 x 6.5 meters was used to allow equipment access to apply manure.

Liquid swine manure application was applied in July 2004 and again in July 2005 at a rate of 90,000 L/ha (8000 gal/acre) or 50 kg/ha actual N using a custom built manure application truck developed by PAMI (Prairie Agriculture Machinery Institute). The toolbar on the truck was modified to offset the broadcast delivery of the manure with the intent of getting a uniform 1.75 meter spread of manure from the centre line of the tree row. This equipment allows for precise application of manure. The manure was applied on both sides of each row of trees resulting in a 3.5 meter band of surface spread manure. In October 2005, treated and check trees were measured for height and DBH.

Results

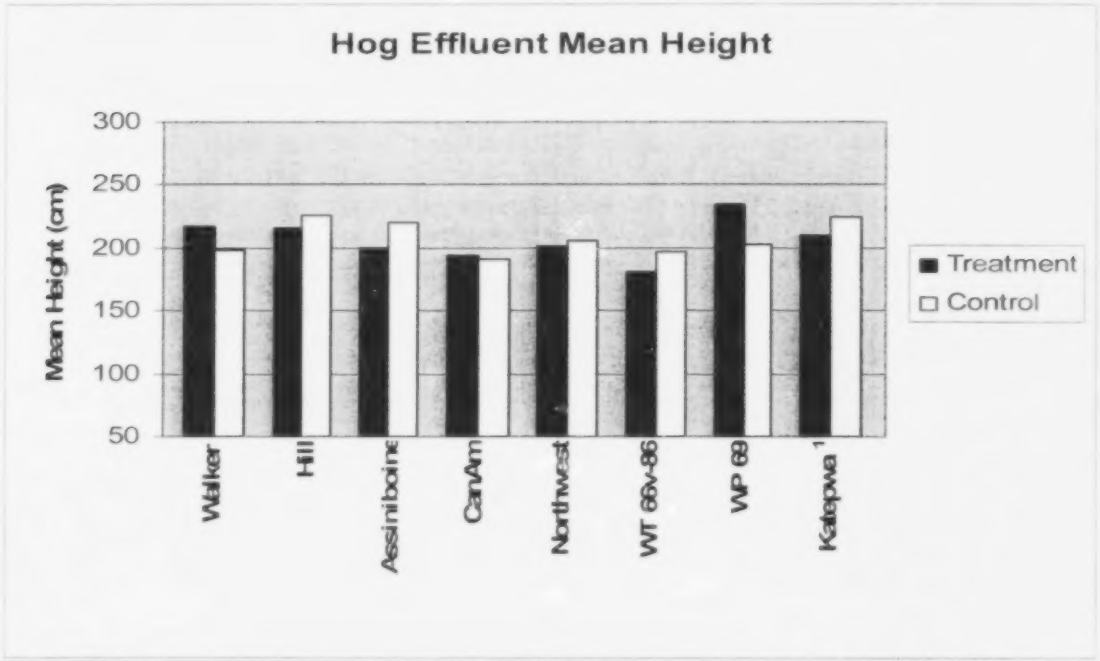
2004 - Height of poplar trees the fall following manure application ranged from 1.9 to 2.2 meters for control trees and 1.8 to 2.3 meters for trees with manure applied. Addition of manure had no significant impact on tree growth, although clones *P.* xWP-69 and P. xWalker showed an increase in growth the differences were not statistically significant.

2005 - In 2005 total height of treated trees range ranged from 243 to 335 cm compared to a range of 247 to 315 cm for control trees. The only clones that showed a significant positive response to manure application were P. xWP-69 and P. xKatepwa. Two clones , P. x Assiniboine and P. xCanAm had a significant growth reduction when manure was applied.

Conclusion

Application of liquid swine manure had no adverse effects on poplar growth, however the concentration of N applied through the manure at 50 kg/ha N was not high enough to result in increased growth. The rate of 80,000 L/ha was the maximum amount of liquid manure possible to apply without significant runoff. For increased application of N, multiple applications spaced 2-3 weeks apart would be required.

Figure 1: 2004 growth of hybrid poplar clones following treatment with hog manure compared to a non-treated control.



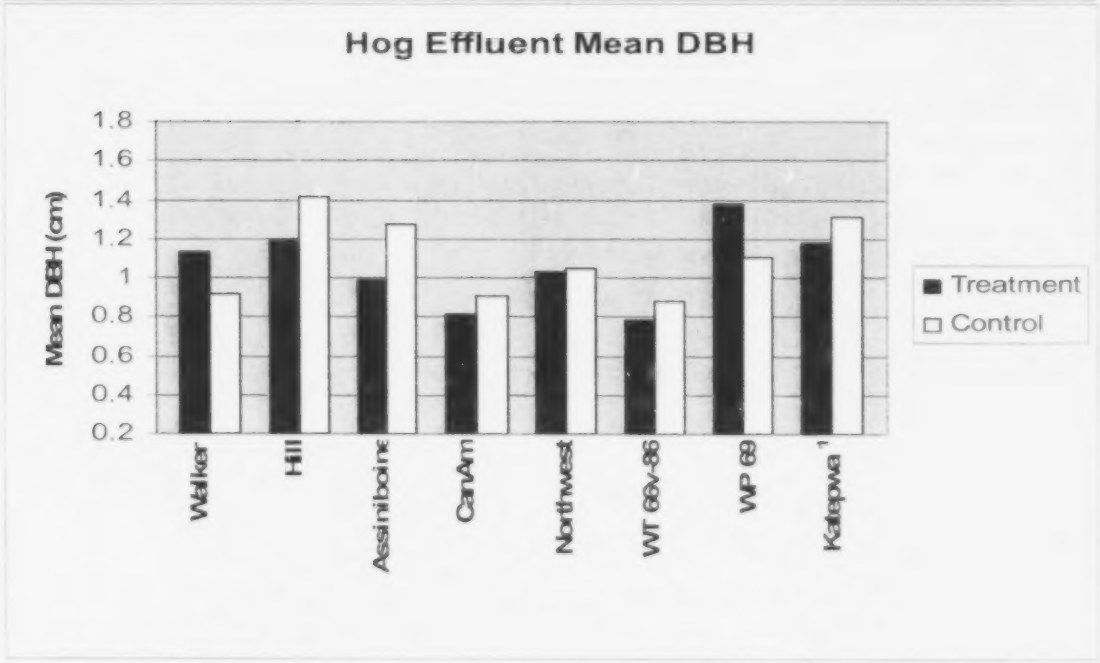
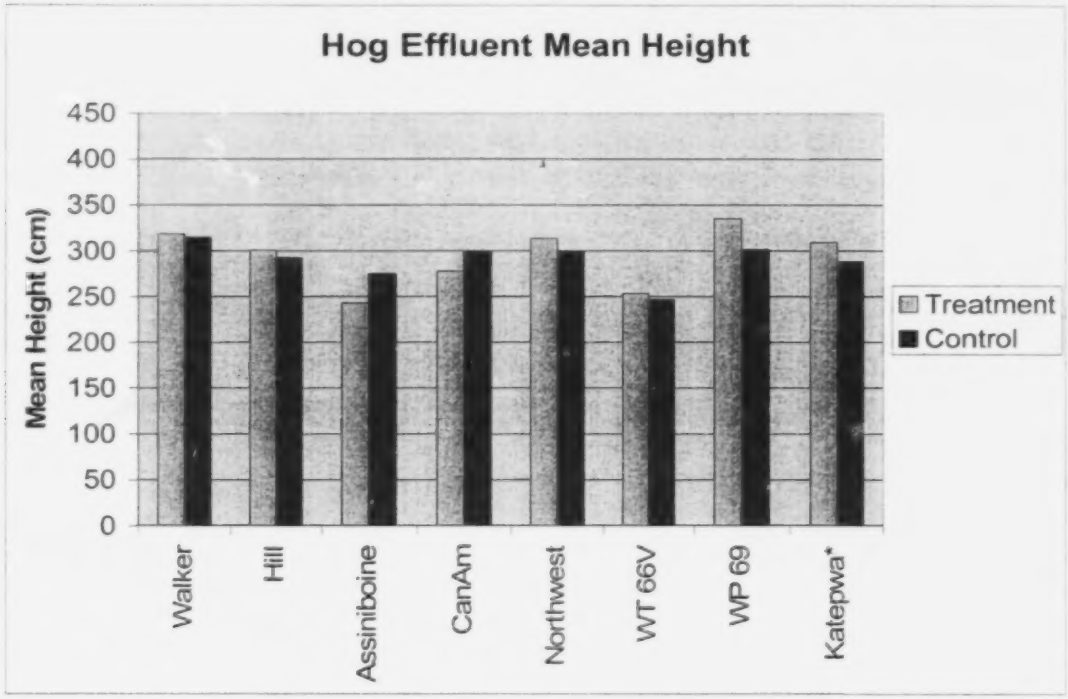
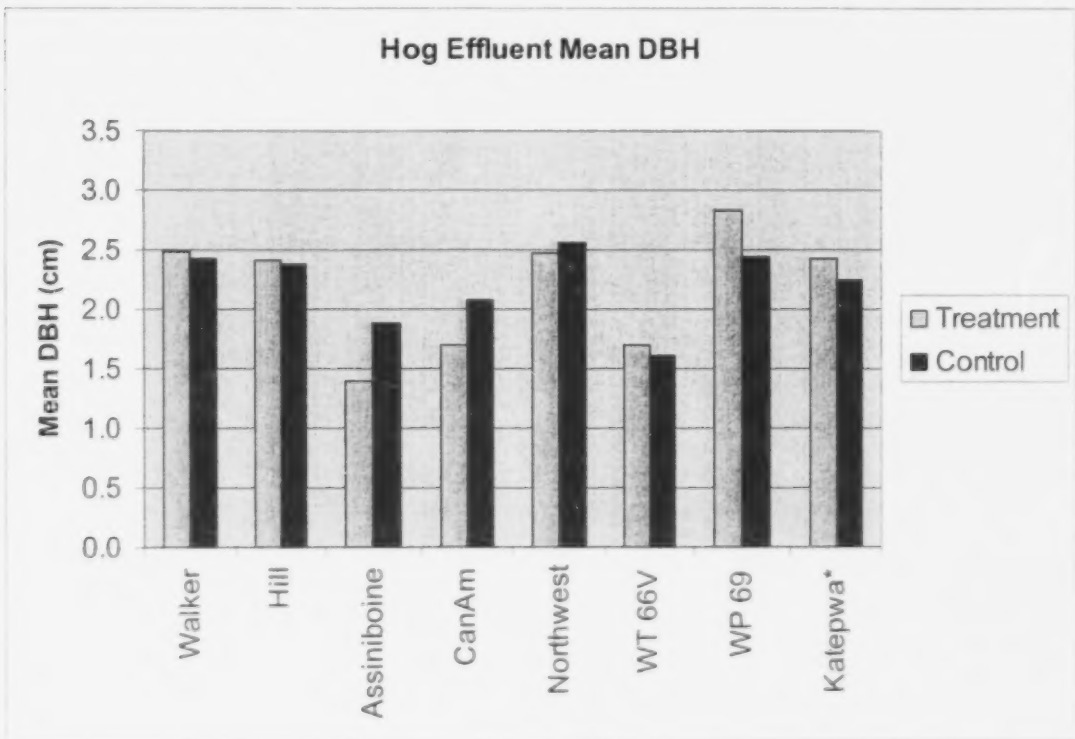


Figure 2: 2005 growth of hybrid poplar clones following treatment with hog manure compared to a non-treated control.





2.5 Establishment of Tree Plots for Future Research

Tree plots for future research were established at Meadow Lake sites A (MLA) and B (MLB). At Meadow Lake A, two plots were established. A 1.7 hectare plot consisting of two hybrid poplar clones, Katepwa (1,023 trees) and WT-66V (868 trees). This plot will be available for future research projects. In addition 1.8 hectare plots consisting of four clones (Walker, Hill, Katepwa and WP-69) at both Meadow Lake sites A and B are being used for a fertility study conducted by the University of Saskatchewan with funding from the Saskatchewan Forest Centre, Forest Development Fund.

3.0 Personnel

William Schroeder (AAFC-PFRA) is the principal investigator and Salim Silim (AAFC-PFRA), Don Reynard (AAFC-PFRA), Dan Walker (AAFC-PFRA), John Kort (AAFC-PFRA), Chris Stefner (AAFC-PFRA) and Lyle Alspach (AAFC-PFRA) provided scientific support. Ken Van Rees (University of Saskatchewan), Roger Nesdoly (Mistik Management) and Grant Harrison (PRT Nurseries) are co-investigators. Technical support staff for the project include Garth Inouye and Colin Phillips (summer student).

4.0 Equipment

No equipment was purchased with funds from ADF. All equipment used was in-kind contribution by the AAFC-PFRA Shelterbelt Centre and University of Saskatchewan.

5.0 Project Photos

Project photos in digital format taken in this reporting period are attached in electronic format.

6.0 Agriculture Development Fund Acknowledgement

ADF was acknowledged during contact with the public, cooperators and during presentations at meetings.

7.0 Public Information Materials and Technology Transfer

Posters describing project activities were prepared and displayed at the AAFC-PFRA Shelterbelt Centre Field day (2003 and 2005) and at the Poplar Council of Canada annual meeting (2003 and 2005). Copies of posters are attached. Presentations on project activities were made to the Forest Nursery, Afforestation & Silviculture Practices Workshop in Edmonton AB, December 8, 2003 and to a partner/Collaborator meeting at Meadow Lake on October 15, 2003. Annual tours of the Meadow Lake project sites was given to project collaborators that included representatives of Mistik Management, University of Saskatchewan, Saskatchewan Agriculture, Food and Rural Revitalization, Saskatchewan Forest Centre and Pacific Forest Regeneration.

A poplar farming field day was held August 26, 2004 at the Meadow Lake project site. The field day provided the opportunity for farmers and land managers to view the progress of different projects that focus on poplar farming systems in Saskatchewan. The field day was conducted in partnership with the Saskatchewan Forest Centre, PRT Nursery, Mistik Management Ltd., Tolko Industries Ltd., University of Saskatchewan and the Natural Science and Engineering Research Council (NSERC).

A total of 65 participants learned about different aspects of poplar farming management. The performance of various hybrid poplar clones was highlighted. Weed control methods and equipment were displayed and discussed. The survival rate of different varieties and the effect of diverse fertilizer rates were shown. Participants were provided with handouts and factsheets

A concerted effort was made to provide information on the project to participants at the AAFC-PFRA Shelterbelt Centre Field day at Indian Head July 10, 2003 and July 21, 2005. The project hosted a display that featured posters describing project activities and project staff answered questions from the public. A portion of the field day research tour was dedicated to providing information on hybrid poplar farming information being developed by the project.

In 2005 the project co-hosted a field tour for conference attendees at the joint meeting of the Canadian Institute of Forestry and Poplar. The field tour highlighted project activities through displays and field presentations.

In 2005 a factsheet "Hybrid Poplar Clones for Saskatchewan" was developed.

8.0 Appendix

1. Report photos
2. Project posters presented at conferences and meetings
3. Plantation signs
4. Project Site maps
5. Project plot maps
6. Poplar site suitability maps